Lloyd's Register

Rules for the Manufacture, Testing and Certification of Materials, July 2010

Notice No. 1

Effective Date of Latest Amendments:

See page 1

Issue date: February 2011

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RULES FOR THE MANUFACTURE, TESTING AND CERTIFICATION OF MATERIALS, *July 2010*

Notice No. 1

This Notice contains amendments within the following Sections of the *Rules for the Manufacture, Testing and Certification of Materials, July 2010.* The amendments are effective on the dates shown:

Chapter	***Section***	***Effective date***
1	3, 5, 6	1 July 2011
2	2	1 July 2011
3	5, 9	1 July 2011
5	3	1 July 2011
9	1, 2, 3	1 July 2011
10	1, 2, 3, 4, 5, 6, 7	1 July 2011
11	1, 3, 8	1 July 2011
12	2, 4	1 July 2011
13	1, 2, 4, 8	1 July 2011
14	1	1 July 2011

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules for the Manufacture, Testing and Certification of Materials July 2010* are to be read in conjunction with this Notice No. 1. The status of the Rules is now:

Rules for Materials	Effective date:	July 2010
Notice No. 1	Effective date:	1 July 2011 & Corrigenda

Chapter 1

General Requirements

Effective date 1 July 2011

■ *Section 3*
Certification of materials

3.1 General

3.1.4 Where these Rules allow for the issue of a manufacturer's certificate for materials, either validated by an LR Surveyor, or bearing the Materials Quality Scheme mark, the manufacturer is to ensure that ~~two copies~~ a copy of the certificate ~~are~~ is supplied to LR.

■ *Section 5*
Non-destructive examination

5.4 Non-destructive examination procedures

(*Part only shown*)
5.4.1 All non-destructive examinations are to be carried out to a procedure that is representative of the item under inspection. As a minimum the procedures are to be in accordance with the following:

(k) The minimum optical density within the area of interest on a radiograph is to be equal to or greater than 2,0 for gamma ray and 1,8 for X-ray. A maximum density of 4,0 is acceptable.

~~(k)~~ (l) Procedures are to include the method and requirements for equipment calibrations and functional checks.

(m) Procedures are to be approved by an operator qualified to a minimum of Level III in accordance with a recognised standard.

(n) The Surveyor will review procedures for compliance with this Section.

■ *Section 6*
References

6.1 General

6.1.1 The location of National and International Standards referenced in these Rules are shown in Table 1.6.1.

Table 1.6.1 List of National and International Standards

Rule reference	Standard
Chapter 1 – General Requirements	ISO 9001: 2008
Chapter 2 – Testing Procedures for Metallic Materials	ISO 6892-1: 2009 ISO 185: 2005 ISO 2566-1: 1999 ISO 148-1: 2009 ISO 7500-1: 2004 EN 10045-1: 1990 ASTM E23-07
Chapter 3 – Rolled Steel Plates, Strip, Sections and Bars	EN 10160: 1999 ASTM A578-07 ASTM E112-96 (2004)e2 ASTM E381-01 (2006) ASTM A255-07 (e1)
Chapter 4 – Steel Castings	ISO 1161: 1984/Amendment 1: 2007
Chapter 5 – Steel Forgings	ASTM E112-96 (2004)e2
Chapter 8 – Aluminium Alloys	ASTM G66-99 (2005)e1 ASTM G67-04
Chapter 9 – Copper Alloys	ASTM E272-99 (2004)
Chapter 10 – Equipment for Mooring and Anchoring	ISO 1704: 2008 ISO 1834: 1999 ISO 4565: 1986 ASTM E112-96 (2004)e2 ASTM E381-01 (2006) ASTM A255-07 (e1)
Chapter 11 – Approval of Welding Consumables	ISO 3690: 2000 ISO 10042: 2005 ASTM G48-03 (2009)
Chapter 12 – Welding Qualifications	ISO 6947: 1997 ISO 5817: 2007 ISO 6520-1: 2007 ISO 6507-1: 2005 ISO 10042: 2005
Chapter 13 – Requirements for Welded Construction	ISO 9712/Cor1: 2006 EN 473: 2008 ISO 6520-1: 2007 SNT-TC-1A: 2006 ISO 10042: 2005
Chapter 14 – Plastics Materials	ISO 527-2: 1993 ISO 178: 2001 ISO 62: 2008 ISO 75-2: 2004 ISO 604: 2002 ISO 527-4: 1997 ISO 14125: 1998 ISO 14130: 1997 ISO 1172: 1996 ISO 1922- 2001 ASTM C273/C273M-07^{a} ASTM C393/C393M-06 ISO 845- 2006 ASTM C297/C297M-04 ISO 844-2007 ISO 1922-2001 ISO 180-2000 DIN EN59 ISO 175: 1999

Chapter 2

Testing Procedures for Metallic Materials

Effective date 1 July 2011

■ *Section 2*
Tensile tests

2.1 Dimensions of test specimens

2.1.15 Tolerances on tensile specimen dimensions are to be in accordance with ~~ISO 6892-98~~ ISO 6892-1 or another Recognised Standard as appropriate.

Chapter 3

Rolled Steel Plates, Strip, Sections and Bars

Effective date 1 July 2011

■ *Section 5*
Steels for machinery fabrications

5.1 General

5.1.2 The minus tolerances for ~~plates and wide flats~~ products for machinery structures are to be in accordance with Table 3.5.1.

Table 3.5.1 Under thickness tolerances

Nominal thickness, t (mm)	~~Under thickness tolerance (mm)~~ Minus tolerance (mm)
~~≥5 <8~~ $5 \le t < 8$	–0,4
~~≥8 <15~~ $8 \le t < 15$	–0,5
~~≥15 <25~~ $15 \le t < 25$	–0,6
~~≥25 <40~~ $25 \le t < 40$	–0,8
~~≥40~~ $t \ge 40$	–1,0

■ *Section 9*
Bars for welded chain cables

9.1 Scope

9.1.1 Provision is made in this Section for rolled steel bars intended for the manufacture of three Grades (U1, U2 and U3) of stud link chain cable for the anchoring and mooring of ships and ~~three~~ five Grades (R3, R3S, ~~and~~ R4, R4S and R5) of offshore mooring cable.

9.1.3 For the offshore grades, R3, R3S, ~~and~~ R4, R4S and R5, approval is confined to bar to be supplied to a nominated chain manufacturer and will be given only after successful testing of a completed chain. Separate approvals are required if bar is to be supplied to more than one cable manufacturer. Approval of a higher grade does not cover approval of a lower grade, as all grades must be individually approved.

9.2 Manufacture

9.2.1 All grades of bar material ~~is~~ are to be made from killed steel, and~~,~~ all grades of bar material except for Grade U1 chain cables, ~~is~~ are to be fine grained. For Grades R4S and R5 the austenite grain size is to be 6 or finer, in accordance with ASTM E112.

9.2.3 The rolling reduction ratio of bars for Grades R3, R3S, R4, R4S and R5 must be at least 5:1.

9.3 Chemical composition

9.3.2 For Grades R3, R3S, ~~and~~ R4, R4S and R5 the chemical composition is to comply with an approved specification, *see* 9.2.2.

9.3.3 For Grade R4, R4S and R5 chain cable the steel should contain a minimum of 0,2 per cent molybdenum. The reported composition is to include the contents of antimony, arsenic, tin, copper, nitrogen, aluminium and titanium.

9.3.4 For Grades R4S and R5 the steel used must be vacuum degassed.

9.4 Heat treatment

9.4.2 For Grades U1 and U2, the samples selected from each batch may be tested either in the as-rolled condition, or after heat treatment where the chain is to be used in the heat treated condition, in full cross-section and in a manner simulating the heat treatment applied to the finished cable.

9.4.3 For Grades U3, R3, R3S, ~~and~~ R4, R4S and R5 the sample is to be tested after heat treatment as detailed in 9.4.2.

9.5 Embrittlement tests

9.5.1 For Grades R3, R3S, ~~and~~ R4, R4S and R5 the bar manufacturer is to provide evidence that the material is not susceptible to strain ageing or to temper brittleness under the conditions of manufacture of the chain. The results of the relevant tests are to be reported to LR at the approval stage. Approval will be restricted to the specified steel composition and if later this is altered then re-approval will be required. Temper brittleness testing may be waived if the chain is to be quenched after tempering.

9.5.2 Each heat of steel bars of ~~grade~~ grades R3S, ~~and~~ R4, R4S and R5 ~~steel bars~~ is to be tested for hydrogen embrittlement (*see* Ch 2,5.3). In the case of continuous casting, test samples representing both the beginning and the end of the charge are to be taken. In the case of ingot casting, test samples representing two different ingots are to be taken.

9.6 Mechanical tests

9.6.1 Bars of the same nominal diameter are to be presented for test in batches of 50 tonnes or fraction thereof from the same cast. A suitable length from one bar in each batch is to be selected for test purposes. Test pieces are to be taken from the positions as shown in Fig. 3.9.1.

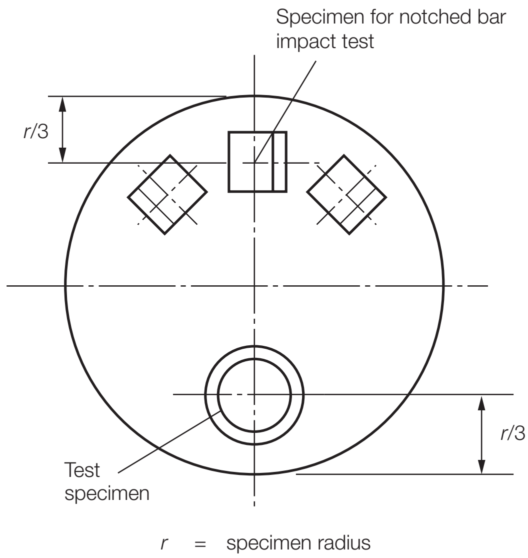


Fig. 3.9.1 Sampling of steel bars

9.6.2 For all grades, one tensile test is to be taken from each sample length selected. Additionally, for Grades U3, R3, R3S, ~~and~~ R4, R4S and R5 material, one set of three Charpy V-notch impact test specimens is to be prepared. Impact tests are also required for Grade U2 when the chain is to be supplied in as-welded condition.

9.6.4 Failure to meet the requirements will result in the rejection of a batch of material, unless it is clearly attributed to improper simulated heat treatment. This is to be confirmed to be to the satisfaction of LR, and further heat treatment and testing will be required prior to acceptance.

9.7 Structure and hardenability tests

9.7.1 For Grades R4S and R5, the following tests are to be carried out on each heat:

(a) Assessment and quantification of the level of non-metallic micro inclusion. These must be acceptable for the final product.

(b) Macro etching on a representative sample, in accordance with ASTM E381 or equivalent. This must be free from any injurious segregation or porosity.

(c) Jominy hardenability tests in accordance with ASTM A255 or equivalent.

~~9.7~~ 9.8 Dimensional tolerances

~~*9.7.1*~~ *9.8.1* The tolerances on diameter and ovality of the bar are to be in accordance with Table 3.9.3.

~~9.8~~ 9.9 Non-destructive examination

~~*9.8.1*~~ *9.9.1* For the R3, R3S, ~~and~~ R4, R4S and R5 grades all bars are to be inspected by a magnetic particle or eddy current method and are also to be subjected to ultrasonic examination.

9.9.2 All non-destructive examination is to be carried out in accordance with approved procedures, in accordance with Ch 1,5.

9.9.3 All non-destructive examination operators are to be qualified in the method of non-destructive examination to a minimum of Level II in accordance with a recognised standard.

9.9.4 The bars are to be free from pipes, cracks, flakes, and injurious surface defects such as seams, laps, and rolled-in mill scale. Longitudinal discontinuities may be removed by blending to a smooth contour provided that their depth is not greater than 1 per cent of the bar diameter, and that the required diameter tolerances are not compromised. The contour radiuses are to be a minimum of four times the excavation depth.

~~*9.8.2*~~ *9.9.5* The frequency of non-destructive testing may be reduced at the discretion of LR, provided statistical evidence is available that the required quality is achieved consistently.

Table 3.9.2 **Mechanical properties** *(Part only shown)*

Grade	Yield stress N/mm^2 minimum	Tensile strength N/mm^2	Elongation on $5,65\sqrt{S_0}$ % minimum	Reduction of area % minimum	Charpy V-notch impact tests		
					Test temperature °C	Average energy J minimum	Average energy flash weld J minimum
R4	580 (*see* Note 3)	860 minimum (*see* Note 3)	12	50	–20	50	36
Grade R4S (*see* Note 4)	700 (*see* Note 3)	960 minimum (*see* Note 3)	12	50	–20	56	40
Grade R5 (*see* Note 4)	760 (*see* Note 3)	1000 minimum (*see* Note 3)	12	50	–20	58	42

NOTES
1. Impact tests may be waived when the chain cable is to be supplied in one of the heat treated conditions given in Table 10.2.3.
2. Testing may be carried out at either 0°C or –20°C, at the option of LR.
3. The ratio of yield strength to tensile strength should not exceed 0,92.
4. The maximum hardness for R4S is to be HB330, and for R5 is to be HB340.

Table 3.9.3 **Dimensional tolerance of bar stock**

Nominal diameter mm	Tolerance on diameter mm	Tolerance on roundness ($d_{max} – d_{min}$) mm
~~≤25~~	~~–0/+1,0~~	~~0,60~~
≤20	–0/+5,0	0,60
>20 ≤25	–0/+1,0	0,60
>26 ≤35	–0/+1,2	0,80
>36 ≤50	–0/+1,6	1,10
>51 ≤80	–0/+2,0	1,50
>81 ≤100	–0/+2,6	1,95
>101 ≤120	–0/+3,0	2,25
>121 ≤160	–0/+4,0	3,00
>161 ≤210	–0/+5,0	4,00

~~9.9~~ 9.10 Identification

~~9.9.1~~ 9.10.1 Each bar is to be identified in accordance with 1.10 and, in addition, is to be marked with the appropriate grade of chain cable.

~~9.10~~ 9.11 Certification of materials

~~9.10.1~~ 9.11.1 Each consignment of bars is to be accompanied by a certificate of a type and in accordance with 1.11 but with the addition of the grade of chain cable, the rolling reduction ratio, the results of the micro inclusion, macro etch and hardenability tests, where required by each grade.

Chapter 5

Steel Forgings

Effective date 1 July 2011

■ *Section 3*
Forgings for shafting and machinery

3.4 Mechanical tests

3.4.12 For screwshafts intended for ships with the notation **Ice Class 1AS** or **1A** and where the connection between the propeller and the screwshaft is by means of a key, a set of three Charpy V-notch impact tests (longitudinal test) is to be made on material from the propeller end of each shaft. The tests are to be carried out at –10°C and the average energy value is to be not less than ~~27~~ 20 J.

Chapter 9

Copper Alloys

Effective date 1 July 2011

■ *Section 1*
Castings for propellers

1.4 Chemical composition

(*Part only shown*)

Table 9.1.1 Chemical composition of propeller and propeller blade castings

Alloy designation	Chemical composition of ladle samples %							
	Cu	Sn	Zn	Pb	Ni	Fe	Al	Mn
Grade Cu 1 Manganese bronze (high tensile brass)	52–62	0,1–1,5	35–40	0,5 max.	1,0 max.	0,5–2,5	0,5–3,0	0,5–4,0
Grade Cu 2 Ni-manganese bronze (high tensile brass)	50–57	0,1–1,5	33–38	0,5 max.	2,5–8,0	0,5–2,5	0,5–2,0	1,0–4,0
Grade Cu 3 Ni-aluminium bronze	77–82	0,1 max.	1,0 max.	0,03 max.	3,0–6,0 (*see* Note)	2,0–6,0 (*see* Note)	7,0–11,0	0,5–4,0
Grade Cu 4 Mn–aluminium bronze	70–80	1,0 max.	6,0 max.	0,05 max.	1,5–3,0	2,0–5,0	6,5–9,0	8,0–20,0
NOTE For Naval ships, the nickel content is to be higher than the iron content.								

1.8 Inspection and non-destructive examination

1.8.10 On completion of machining and grinding, the whole surface of each casting is to be subjected to a dye penetrant inspection in accordance with a ~~standard or specification approved by~~ procedure acceptable to LR.

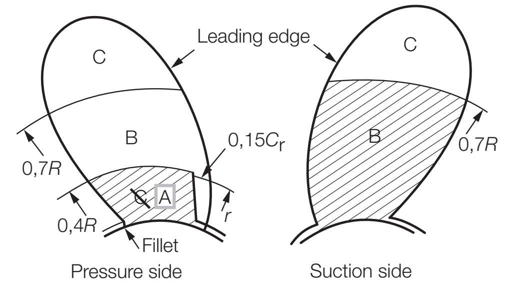
1.8.12 Dye penetrant inspections on Zones B and C are to be performed by the manufacturer and may be witnessed ~~by the Surveyor at his~~ at the Surveyor’s request.

1.8.18 Where it is suspected that a casting contains internal defects, radiographic and/or ultrasonic examination may be required by the Surveyor. The acceptance criteria are to be agreed between the manufacturer and LR in accordance with a recognised standard. The standard ASTM E272-99 (Severity Level 2) or equivalent is to be the radiographic acceptance standard for copper alloy castings. Ultrasonic testing of Cu 1 and Cu 2 is not considered in these Rules. For Cu 3 and Cu 4, ultrasonic inspection of defects may be possible and is to comply with the requirements for steel castings.

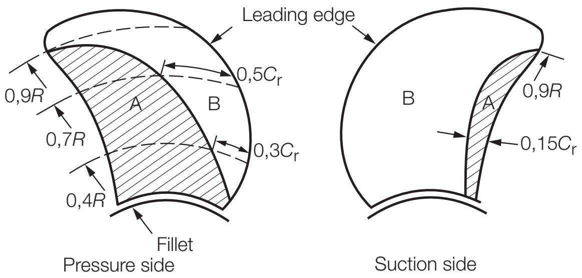
1.10 Weld repair procedure

1.10.4 Defects to be repaired by welding are to be removed completely by mechanical means (e.g. grinding, chipping or milling). Removal of defects in accordance with the requirements for Zone A is to be demonstrated by dye penetrant inspection in the presence of the Surveyor. The excavation is to be prepared in a manner which will allow good fusion and is to be clean and dry.

1.8 Inspection and non-destructive examination



(a) Blades with propeller skew angles of 25° or less



(b) Blades with propeller skew angles of greater than 25°

R = propeller radius
C_r = chord length at radius r

NOTE
For a definition of skew angle, *see* the relevant Rules

Fig. 9.1.2 Severity zones in all propeller blades

1.11 Identification

1.11.1 Castings are to be clearly marked by the manufacturer in accordance with the requirements of Chapter 1. The following details are to be shown on all castings which have been accepted:

(a) Identification mark which will enable the full history of the item to be traced.
(b) Alloy grade.
(c) LR or Lloyd's Register and the abbreviated name of ~~LR's~~ LR local office.
(d) Personal stamp of Surveyor responsible for the final inspection.
(e) Date of final inspection.
(f) Skew angle, if in excess of 25°. *See* ~~the relevant Rules~~ Pt 5, Ch 7,1 of the Rules for Ships for the definition of skew angle.

■ *Section 2*
Castings for valves, liners and bushes

2.4 Chemical composition

Table 9.2.2 Chemical compositions of short freezing range alloys: principal elements only

Alloy type	Designation	Chemical composition								Typical applications
		Cu	Ni	Fe	Mn	Cr	Nb	Si	Al	
Copper 30% nickel	Cu Ni30 Fe1 Mn1	64,5 min.	29,0–31,0	0,5–1,5	0,6–1,2	–	–	0,1 max.	–	Flanges, valves and fittings
	Cu Ni30 Fe1 Mn1 Nb Si	Remainder	29,0–31,0	0,5–1,5	0,6–1,2	–	0,5–1,0	0,3–0,7	–	
	Cu Ni30 Cr2 Fe Mn Si (*see* Note 1)	Remainder	29,0–32,0	0,5–1,0	0,5–1,0	1,5–2,0	–	0,15–0,50	–	
Copper 10% nickel	Cu Ni10 Fe1 Mn1	84,5 min.	9,0–11,0	1,0–1,8	1,0–1,5	–	1,0 max.	0,10 max.	–	Flanges, valves and fittings
Aluminium bronze	Cu Al10 Fe5 Ni5	76,0–83,0	4,0–6,0 (*see* Note 2)	4,0–5,5 (*see* Note 2)	3,0 max.	–	–	0,1 max.	8,5–10,5	Bushes, valves and fittings
	Cu Al11 Fe6 Ni6	72,0–78,0	4,0–7,5 (*see* Note 2)	4,0–7,0 (*see* Note 2)	2,5 max.	–	–	0,1 max.	10,0–12,0	

NOTES
1. Normally alloy Cu Ni30 Cr2 Fe Mn Si contains 0,1 to 0,25% titanium and 0,05 to 0,15% zirconium.
2. For Naval ships, the nickel content is to be higher than the iron content.

2.8 Inspection

2.8.2 For valves and other pressure components, dye penetrant inspection is required and the Surveyor is to witness the tests. Unless otherwise agreed, the acceptance criteria to be applied are to meet the requirements of Table 9.2.5, or equivalent.

Table 9.2.5 Visual and surface NDE acceptance criteria for valves and pressure components

Defect type	Acceptance criteria for visual and surface NDE, *see* Note
Linear indications	Not permitted
Porosity	Individual pores are not to exceed 3 mm diameter bleed out, and the sum of the diameters of all indications in an area of 70 x 70 mm is not to exceed 24 mm^2

NOTE
Inspection is to be in accordance with a procedure acceptable to LR.

2.8.3 The accuracy and verification of dimensions are the responsibility of the manufacturer. However, the report on dimensional inspection is to be presented to the Surveyor who may ~~require checks to be made in his presence~~ request to witness confirmatory measurements.

■ *Section 3*
Tubes

3.9 Stress corrosion cracking test

3.9.4 The test is to be carried out in accordance with a National or International Standard recognised by LR or by the test method given in 3.9.5.

3.10 Hydraulic test

3.10.5 Subject to special approval, an automated eddy current test can be accepted in lieu of the hydraulic test. Discontinuous irregularities on the external and internal surfaces of the tubes are permitted if they are within the agreed dimensional tolerances, with the exception of cracks, which are not permitted.

Chapter 10
Equipment for Mooring and Anchoring

Effective date 1 July 2011

■ *Section 1*
Anchors

1.1 Scope

1.1.2 This Section is applicable to the following types of anchor:
(a) Ordinary.
(b) High holding power (HHP).
(c) Super high holding power (SHHP).

~~*1.1.2*~~ *1.1.3* In the context of this Section, the reference to swivels refers to those directly attached to the anchor shank in lieu of the conventional ‘D’ shackle. For other mooring equipment swivels, *see* 2.13.

1.3 Cast steel anchors

~~*1.3.2* Where acid soluble aluminium content is controlled in the range 0,015 per cent to 0,040 per cent, the nitrogen content need not be determined for each cast, provided that random checks are carried out to the satisfaction of LR.~~

~~*1.3.3*~~ *1.3.2* Special consideration will be given to the use of other grades of steel for the manufacture of swivels.

~~*1.3.4*~~ *1.3.3* To confirm the quality of cast anchor components, the ~~surveyor may require~~ Surveyor is to witness drop and~~/or~~ hammering tests~~ to be carried out~~.

Existing paragraphs 1.3.5 *and* 1.3.6 *have been renumbered* 1.3.4 *and* 1.3.5.

1.3.6 As part of the manufacturer’s works approval, consideration may be given to carrying out drop tests in alternative locations to the manufacturer’s when the facilities and location are not suitable.

1.5 Fabricated steel anchors

~~*1.5.2* The manufacturing process is to be in accordance with approved welding procedures, using approved welding consumables and carried out by qualified welders.~~

1.5.2 Fabricated anchors are to be manufactured in accordance with Chapter 13.

1.6 Rectification

1.6.5 Rectification of defective castings, forgings or fabricated anchors by welding is to be carried out using qualified weld procedures in accordance with Ch 12,1 and Ch 12,2, and in accordance with Ch 13,1 and Ch 13,2.

1.7 ~~High holding power (HHP) anchors~~ Super high holding power (SHHP) anchors

~~*1.7.1* Anchor designs for which approval is sought as high holding power anchors are to be tested at sea to show that they have holding powers of at least twice those of approved standard stockless anchors of the same mass.~~

1.7.1 The impact test requirements for SHHP anchor shackles are to be in accordance with the requirements for Grade U3 in Table 10.2.1.

~~*1.7.2* If approval is sought for a range of sizes, then at least two sizes are to be tested. The smaller of the two anchors is to have a mass not less than one-tenth of that of the larger anchor, and the larger of the two anchors tested is to have a mass not less than one-tenth of that of the largest anchor for which approval is sought.~~

~~*1.7.3* High holding power anchors are to be of a design that will ensure that the anchors will take effective hold of the sea bed without undue delay and will remain stable, for holding forces up to those required by 1.7.1, irrespective of the angle or position at which they first settle on the sea bed when dropped from a normal type of hawse pipe. In case of doubt, a demonstration of these abilities may be required.~~

~~*1.7.4* The test should normally be carried out from a tug or other suitable vessel, and the pull measured by dynamometer or derived from recently verified curves of tug rev/min against bollard pull. The tests are to be conducted on not less than three different types of bottom, which should normally be soft mud or silt, sand or gravel, and hard clay or similarly compacted material. A scope of 10 is recommended for the anchor cable, but in no case should a scope of less than 6 be used. The same scope is to be used for the anchor for which approval is sought and the anchor that is being used for comparison purposes.~~

1.9 Proof test of anchors

~~*1.9.2* The anchor is to be visually examined before application of the proof test load to ensure that it is free from surface defects of a harmful nature.~~

1.9.2 The anchor is to be visually examined before application of the proof test load to ensure that it is free from cracks, notches, inclusions and other surface defects that would impair the performance of the product.

1.9.8 After proof testing, all accessible surfaces are to be visually inspected by the Surveyor.

1.9.9 Following proof testing, NDE is to be conducted as described in Table 10.1.2 for ordinary and HHP anchors and Table 10.1.3 for SHHP anchors.

Table 10.1.2 NDE requirements following proof testing for Ordinary and HHP anchors

Location	Method of NDE
Feeder heads, runners and risers of castings	Magnetic particle inspection and ultrasonic test, *see* Note 1
All welds	Magnetic particle inspection
Forged components	Not required
Fabrication welds	Magnetic particle inspection

NOTES
1. *See also* 1.9.10.
2. Penetrant testing is to be used in lieu of magnetic particle testing for stainless steel, aluminium and copper alloy anchors.

Table 10.1.3 NDE requirements following proof testing for SHHP anchors

Location	Method of NDE
Feeder heads, runners and risers of castings	Magnetic particle inspection and ultrasonic test, *see* Note 1
All surfaces of castings	Magnetic particle inspection
All welds	Magnetic particle inspection
Forged components	Not required
Fabrication welds	Magnetic particle inspection

NOTES
1. *See also* 1.9.10.
2. Additionally, all surfaces of all SHHP anchors are to be surface inspected by the magnetic particle or penetrant method as appropriate.
3. Penetrant is to be used in lieu of magnetic particle testing for stainless steel, aluminium and copper alloy anchors.

1.9.10 Each casting is to be subjected to ultrasonic inspection in the region of runners and risers, or where excess material has been removed by thermal methods. This examination is to extend around the whole periphery of the casting and for a distance of *t*/3 beyond the area affected, where *t* is the maximum thickness. In addition, random areas are to be selected by the Surveyor and examined.

1.9.11 Acceptance criteria for castings are to be in accordance with Chapter 4.

1.9.12 Acceptance criteria for forgings are to be in accordance with Chapter 5.

1.9.13 Paint or anti-corrosive coatings are not to be applied until these inspections are completed to the satisfaction of the Surveyor.

1.9.14 On completion of the proof testing, anchors made in more than one piece are to be examined for free movement of their heads over the complete range of rotation.

~~1.10~~ ~~Non-destructive testing~~

~~*1.10.1* All parts must have a clean surface consistent with the method of manufacture and be free from cracks, laps, notches, inclusions and other defects which would be detrimental to service performance.~~

~~*1.10.2* After proof testing all accessible surfaces are to be visually inspected by the Surveyor.~~

~~*1.10.3* Each cast anchor head, shank, shackle and swivel is to be subjected to magnetic particle or dye penetrant inspection on all surfaces. For ordinary and HHP anchors, where drop and hammering tests have been carried out, the inspection may be restricted to the areas around runners and risers, or where excess material has been removed by thermal methods and weld repairs.~~

~~*1.10.4* Each casting is to be subjected to ultrasonic inspection in the region of runners and risers, or where excess material has been removed by thermal methods. This examination is to extend around the whole periphery of the casting and for a distance of *t*/3 beyond the area affected, where *t* is the maximum thickness. In addition, random areas are to be selected by the Surveyor and examined.~~

~~*1.10.5* Ultrasonic testing is not required for ordinary and HHP anchors where drop and hammering tests have been carried out.~~

~~*1.10.6* All fabrication and repair welds are to be subjected to magnetic particle or dye penetrant inspection.~~

~~*1.10.7* Paint or anti-corrosive coatings are not to be applied until these inspections are completed to the satisfaction of the Surveyor.~~

~~1.11~~ 1.10 Clearances and tolerances

Existing paragraphs 1.11.1 to 1.11.5 *have been renumbered* 1.10.1 to 1.10.5.

1.10.6 Unless otherwise agreed, the verification of mass and dimensions is the responsibility of the manufacturer. The Surveyor is only required to monitor this inspection. The mass of the anchor is to exclude the mass of the swivel, unless the swivel is in lieu of the conventional 'D' shackle.

~~1.12~~ 1.11 Identification

~~*1.12.1* All identification marks are to be stamped on one side of the anchor reserved solely for this purpose.~~

1.11.1 Identification marks on the shank are to be approximately level with the fluke tips. On the fluke, these markings are to be approximately at a distance of two thirds from the tip of the bill to the centre line of the crown on the right hand fluke, looking from the crown towards the shank.

~~*1.12.2*~~ *1.11.2* The following details are to be shown on all anchors:

(a) LR or Lloyd's Register and abbreviated name of LR's local office issuing the certificate.
(b) Number of the certificate.
(c) Month and year of test.
(d) Mass (also the letters 'HHP' when approved as high holding power anchors or 'SHHP' when approved as super high holding power anchors).
(e) Mass of stock (in the case of stocked anchors).
(f) National Authority requirements, as applicable.
(g) Manufacturer's mark.

Existing paragraph 1.12.3 *has been renumbered* 1.11.3.

~~1.13~~ 1.12 Certification

~~*1.13.1*~~ *1.12.1* The manufacturer is to provide the Surveyor with a written statement that the anchor has been manufactured and tested in accordance with LR Rules together with the following particulars:

(a) Purchaser's name and order number.
(b) Type of anchor and principal dimensions.
(c) Mass of anchor.
(d) Identification mark which will enable the full history of manufacture to be traced.
(e) Chemical composition.
(f) Details of heat treatment.
(g) Mechanical test results.
(h) Proof load.
(j) Results of the non-destructive examination.
(k) Weld ~~repair details~~ location maps (cast steel anchors only).

Existing paragraph 1.13.2 *has been renumbered* 1.12.2.

~~*1.13.3*~~ *1.12.3* An LR Anchor Certificate is to be issued for the completed anchor which will include the following ~~details~~ particulars:

(a) Manufacturer's name.
(b) Type of anchor.
(c) Mass of anchor.
(d) Grade of materials.
(e) Proof test load.
(f) Heat treatment.
(g) Marking applied to anchor.
(h) Dimensions.

(j) General Approval of an Anchor Design Certificate Number.
(k) Fluke and shank identification numbers.

■ *Section 2*
Stud link chain cables for ships

2.5 Forged chain cables

2.5.3 ~~Stock material may be supplied in the as-rolled condition.~~ The completed forgings are to be heat treated in accordance with Table 10.2.3.

2.7 Welding of studs

2.7.2 The stud ends must be a good fit inside the link, and the weld is to be confined to the stud end opposite the flash-butt weld. The full periphery of the stud end is to be welded. If, however, it can be demonstrated to the Surveyor that the quality of welding is of a high standard then partial peripheral welding may be accepted provided that welds are made only at the sides of the stud and that each run extends continuously for at least 25 per cent of the stud periphery. Weld start/stop positions are not to be located in the plane of the chain cable.

2.7.3 The welds are to be made by qualified welders using an approved procedure and consumables approved to Grade 3 and low hydrogen, in accordance with Chapter 11.

2.7.4 The welds are to be of good quality and free from defects liable to impair the proper use of the chain. Undercuts, end craters and similar stress raising defects shall, where necessary, be ground off.

2.7.5 At least one stud weld within each length of cable is to be inspected using dye penetrant testing in accordance with Ch 1,5 after the chain has been proof loaded. If a crack is found, the stud welds in the adjoining links are to be inspected; if a crack is found in either link, all the stud welds in that length are to be inspected using dye penetrant.

2.7.6 The size of the stud welds is to be in accordance with Fig. 10.3.1.

2.10 Proof load tests

~~*2.10.2* For test purposes, the cable is to be clean and free from paint and anti-corrosive coatings.~~

Existing paragraphs 2.10.3 *to* 2.10.5 *have been renumbered* 2.10.2 *to* 2.10.4.

2.12 Dimensional inspection

2.12.1 After proof testing, the entire chain is to be checked for length, five links at a time with an overlap of two links, which is to include the first five links, to ensure that the chain meets the tolerances given in ~~2.15.4~~ 2.15.5. The measurements are to be made while the chain is loaded to about 10 per cent of the proof load.

2.12.3 If a five link length of chain exceeds the tolerance given in ~~2.15.4,~~ 2.15.5, then the oversize links are to be removed and an approved connecting link inserted.

2.12.8 If the length over five links is less than the nominal, then the chain may be stretched by loading above the specified proof test load provided that the applied load is not greater than ten per cent above the proof test load, and only random lengths of the chain need to be stretched.

2.12.9 Loads used for plastic straining to set studs are not to exceed 0,8 per cent of the proof load unless specifically approved for higher loads.

2.12.10 Paint or anti-corrosive coatings are not to be applied until these inspections are completed to the satisfaction of the Surveyor.

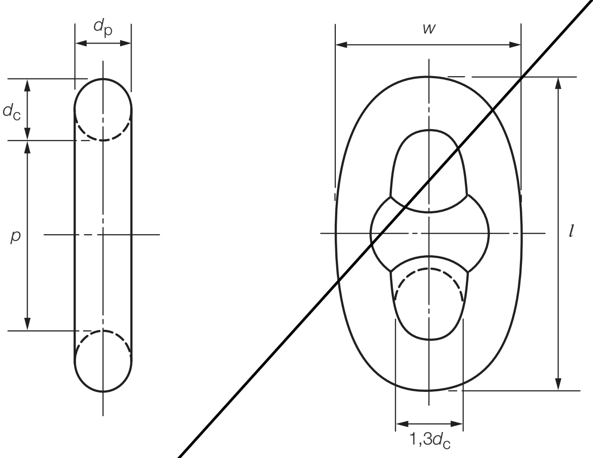
2.13 Fittings for chain cables

2.13.3 All fittings are to be manufactured to an approved manufacturing specification, and provision is to be made for tensile specimens and, where applicable, impact test specimens, *see* Table 10.2.3. The test samples are to be prepared in accordance with 2.4.3 or 2.5.4 as applicable. The test specimens are to be subjected to heat treatment with the fittings they represent. The mechanical test requirements are the same as those for the relevant grade of chain cable, *see* Table 10.2.1. A batch of fittings is to be of the same grade, size and heat treatment charge and to have originated from a single cast of steel. Enlarged and end links need not be tested provided that they are manufactured and heat treated together with the chain cable. Mechanical tests of pins are to be taken in accordance with 3.8.15.

2.13.8 Where the items are of increased dimensions, and have been specially approved, or if material of a higher grade than is specified is used, then the breaking load ~~may~~ is to be applied to each item, and the items so tested included with the outfit. For the purpose of this paragraph, items of increased dimensions are those so designed that their breaking strength is not less than 1,4 times the Rule minimum breaking load of the chain cable with which they are to be used.

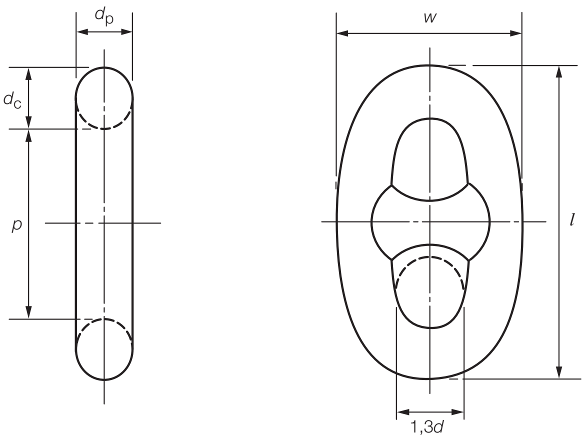
2.15 Dimensions and tolerances

2.15.1 The form and proportion of links and shackles are to be in accordance with ~~ISO/1704-1991~~ ISO/1704-2008, *see* Figs. 10.2.1 to ~~10.2.6~~ 10.2.8. Design of chain cables must be to a standard recognised by LR, such as ISO 1704; alternatively the design may be specifically approved by LR.



d_c = nominal diameter at crown measured in plane of link
d_p = nominal diameter at crown measured perpendicular to plane of link
l = $6d_c$
p = $4d_c$
w = $3,6d_c$ to the nearest millimetre

Fig. 10.2.1 Common link



d_c = nominal diameter at crown measured in plane of link
d_p = nominal diameter at crown measured perpendicular to plane of link
l = $6d$
p = $4d$
w = $3,6d$ to the nearest millimetre

Fig. 10.2.1 Common link

~~*2.15.3* The cross-sectional area at the crown of the link is to have no negative tolerance. The negative tolerance on the diameter at the crown measured in the plane of the link is not to exceed:~~

~~Minus 1 mm when $d_c \le 40$ mm~~
~~Minus 2 mm when 40 mm $< d_c \le 84$ mm~~
~~Minus 3 mm when 84 mm $< d_c \le 122$ mm~~
~~Minus 4 mm when $d_c > 122$ mm~~

~~The plus tolerance on the diameter at the crown measured out of the plane of the link is not to exceed 5 per cent. The cross-sectional area is to be calculated using the average of the diameter measured in the plane of the link d_c, *see* Fig. 10.2.1, and the diameter measured perpendicular to the plane of the link, d_p.~~

2.15.3 The nominal diameter, d, is to be the average of the diameters, measured in the plane of the link, d_c, and perpendicular to the plane of the link, d_p, *see* Fig. 10.2.1. The negative tolerance on the nominal diameter is not to exceed the following:

Minus 1 mm when $d \le 40$ mm
Minus 2 mm when 40 mm $< d \le 84$ mm
Minus 3 mm when 84 mm $< d \le 122$ mm
Minus 4 mm when $d > 122$ mm

The plus tolerance on the diameter at the crown measured out of the plane of the link, d_p, is not to exceed 5 per cent.

2.15.4 The cross-sectional area is to be calculated using the nominal diameter, d. The cross-sectional area at the crown of the link is to have no negative tolerance.

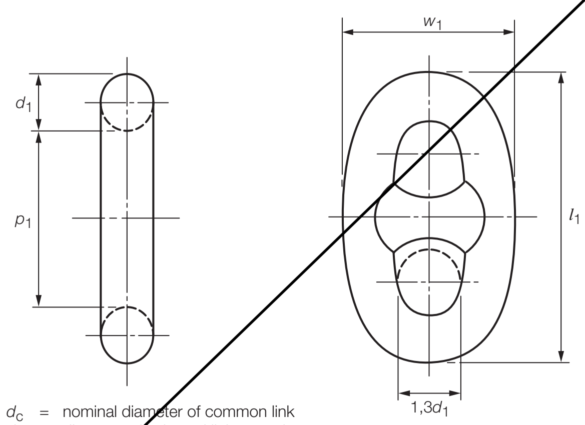
Existing paragraphs 2.15.4 *to* 2.15.6 *have been renumbered* 2.15.5 *to* 2.15.7.

~~*2.15.7*~~ *2.15.8* Studs are to be located in the links centrally, and at right angles to the sides of the link, although the studs of the final link at each end of any length may also be located off-centre to facilitate the insertion of the joining shackle. ~~The following tolerances are acceptable provided that the stud fits snugly and its ends lie flush against the inside of the link:~~

~~Maximum off-centre distance X: 10 per cent of the nominal diameter, d~~
~~Maximum deviation, a from the 90° position: 4°.~~

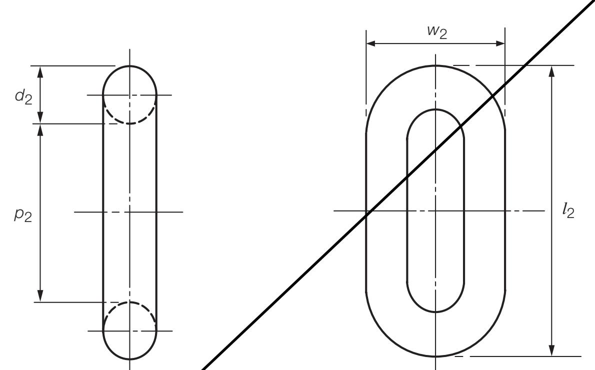
~~The tolerances are to be measured in accordance with Fig. 10.2.7.~~ Tolerances in accordance with Fig. 10.3.1 are acceptable provided that the stud fits snugly and its ends lie flush against the inside of the link.

Existing paragraphs 2.15.8 *to* 2.15.10 *have been renumbered* 2.15.9 *to* 2.15.11.



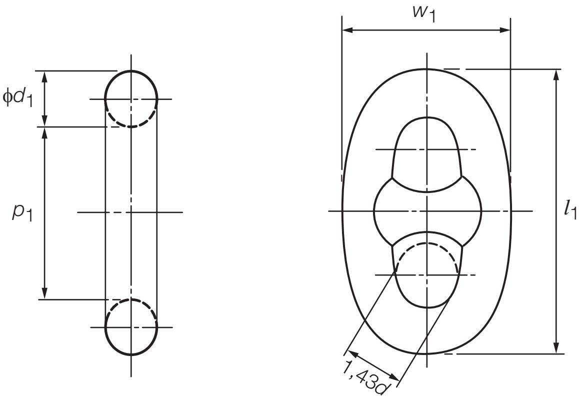
~~d_c = nominal diameter of common link~~
~~d_1 = diameter of enlarged link = $1{,}1d_c$~~
~~l_1 = $6d_1$~~
~~p_1 = $4d_1$~~
~~w_1 = $3{,}6d_1$~~

~~**Fig. 10.2.2 Enlarged link**~~



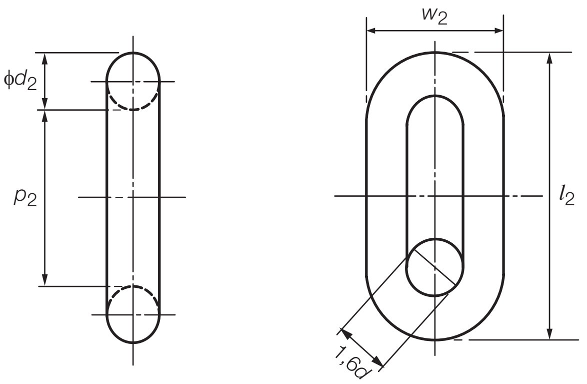
~~d_c = nominal diameter of common link~~
~~d_2 = diameter of end link = $1{,}2d_c$~~
~~l_2 = $p_2 + 2d_2 = 6{,}75d_c$~~
~~p_2 = $4{,}35d_c$~~
~~w_2 = $4d_c$~~

~~**Fig. 10.2.3 End link**~~



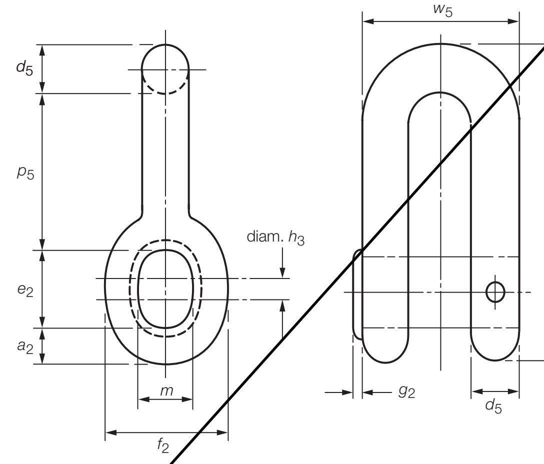
d = nominal diameter of common stud link
d_1 = nominal diameter of enlarged stud link = $1{,}1d$
l_1 = $6d_1 \approx 6{,}6d$
p_1 = $4d_1 \approx 4{,}4d$
w_1 = $3{,}6d_1 \approx 3{,}96d$

Fig. 10.2.2 Enlarged link



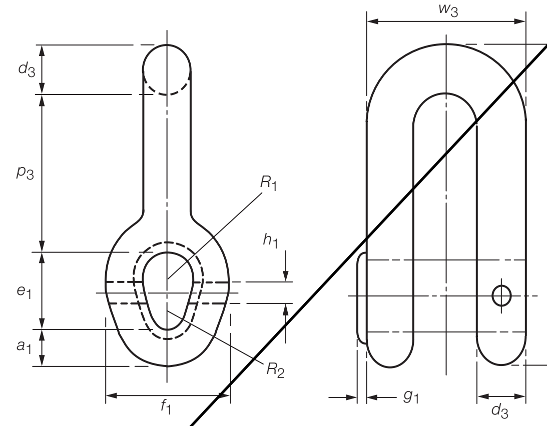
d = nominal diameter of common stud link
d_2 = nominal diameter of end link = $1{,}2d$ ($d_2 - 1{,}2d$)
l_2 = $p_2 + 2d_2 \approx 6{,}75d$
p_2 = $3{,}65d_2 \approx 4{,}35d$
w_2 = $3{,}3d_2 \approx 4d$

Fig. 10.2.3 End link



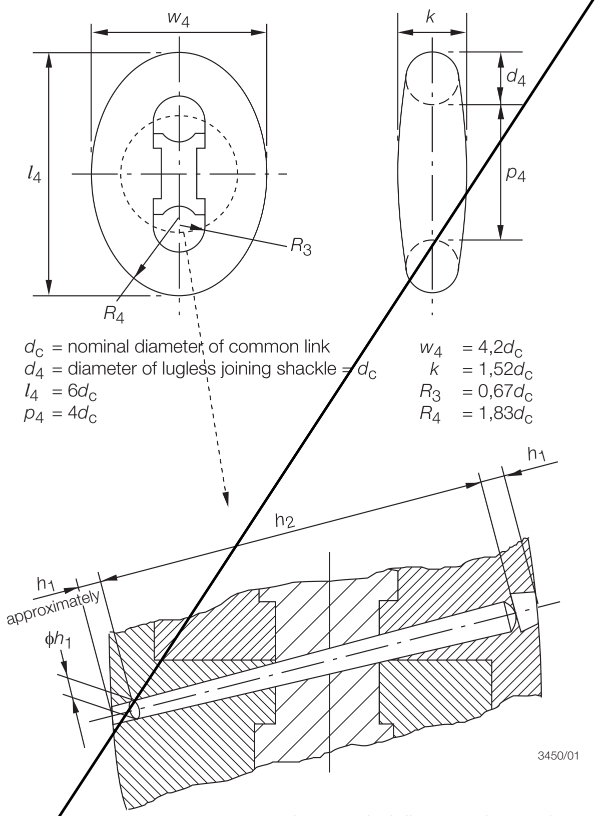
~~d_c = nominal diameter of common link~~
~~d_5 = diameter of end shackle = $1{,}4d_c$~~
~~l_5 = $8{,}7d_c$~~
~~p_5 = $l_5 - (d_5 + a_2 + e_2)^2\ 4{,}6d_c$~~
~~w_5 = $5{,}2d_c$~~
~~a_2 = $0{,}9d_c$~~
~~e_2 = $1{,}8d_c$~~
~~f_2 = $3{,}1d_c$~~
~~g_2 = $0{,}2d_c$~~
~~h_3 = $0{,}4d_c$~~
~~m = $1{,}4d_c$~~

~~**Fig. 10.2.4 End shackle**~~



~~d_c = nominal diameter of common link~~
~~d_3 = diameter of joining shackle = $1{,}3d_c$~~
~~l_3 = $7{,}1d_c$~~
~~p_3 = $l_3 - (d_3 + a_1 + e_1) = 3{,}4d_c$~~
~~w_3 = $4d_c$~~
~~a_1 = $0{,}8d_c$~~
~~e_1 = $1{,}6d_c$~~
~~f_1 = $2{,}8d_c$~~
~~g_1 = $0{,}2d_c$~~
~~h_1 = $0{,}4d_c$~~
~~R_1 = $0{,}6d_c$~~
~~R_2 = $0{,}5d_c$~~

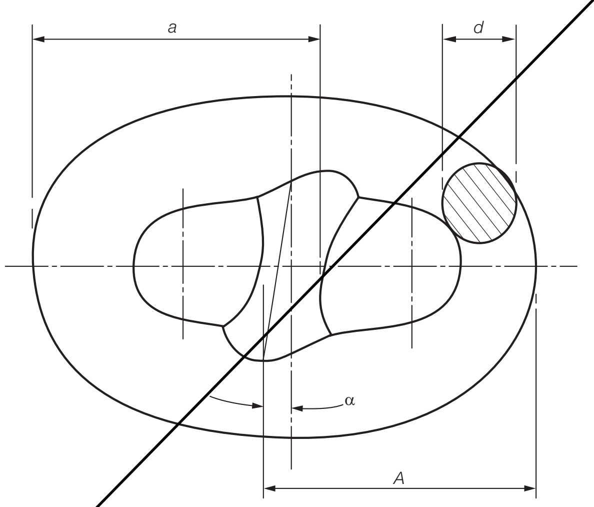
~~**Fig. 10.2.5 Dee shackle**~~



~~d_c = nominal diameter of common link~~
~~d_4 = diameter of lugless joining shackle = d_c~~
~~l_4 = $6d_c$~~
~~p_4 = $4d_c$~~
~~w_4 = $4{,}2d_c$~~
~~k = $1{,}52d_c$~~
~~R_3 = $0{,}67d_c$~~
~~R_4 = $1{,}83d_c$~~

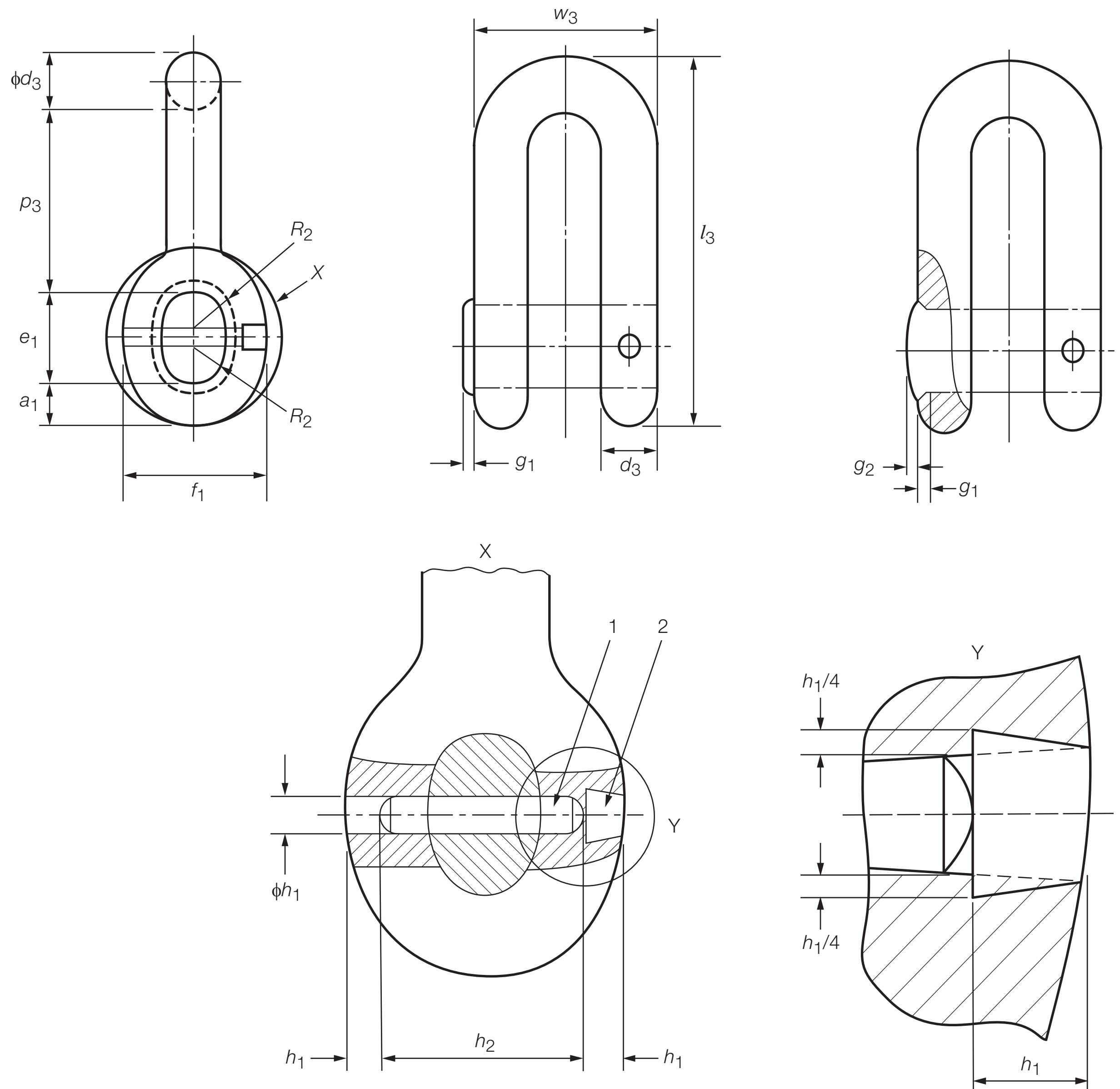
~~h_1 = nominal diameter of taper pin~~
~~h_2 = $3{,}4d_c$ = length of taper pin~~

~~**Fig. 10.2.6 Lugless shackle**~~



~~Off centre distance: $X = \frac{A - a}{2}$~~

~~**Fig. 10.2.7 Stud dimensions**~~

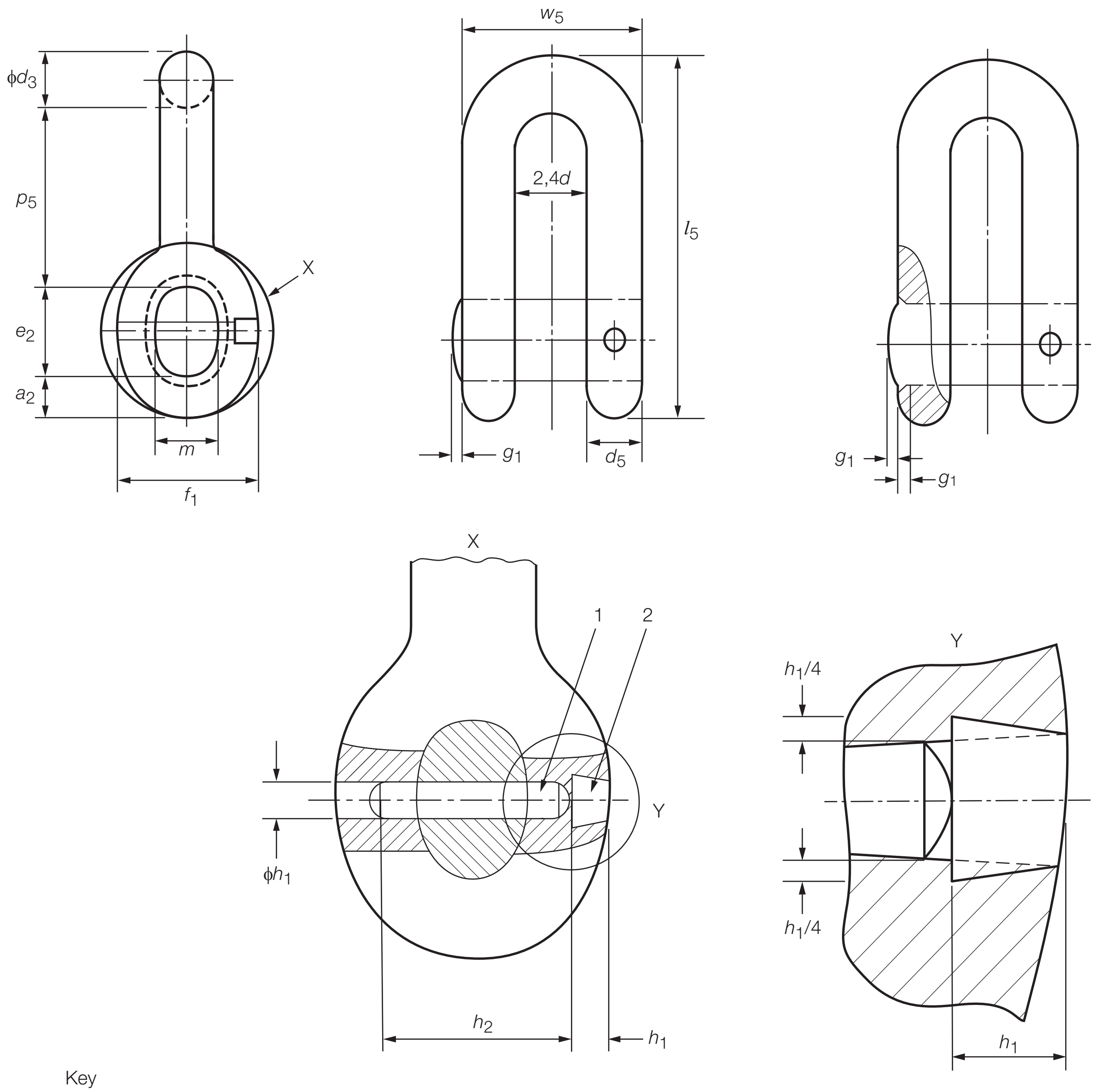


Key
X retaining pin
Y dovetail chamber

d = nominal diameter of common stud link
d_3 = nominal diameter of joining shackle = 1,3d
l_3 = 7,1d
p_3 = $l_3 - (d_3 + a_1 + e_1)$ = 3,4d
w_3 = 4d
a_1 = 0,8d
e_1 = 1,6d

f_1 = 2,8d
g_1 = 0,2d
g_2 = 0,1d
h_1 = nominal diameter of taper pin
h_2 = nominal length of taper pin
R_1 = 0,6d
R_2 = 0,5d

Fig. 10.2.4 End shackle



Key

X	retaining pin
Y	dovetail chamber

d = nominal diameter of common stud link

d_5 = nominal diameter of end shackle = 1,4d

l_5 = 8,7d

p_5 = $l_5 - (d_3 + a_2 + e_2)$ = 4,5d

w_5 = 5,2d

a_2 = 0,9d

e_2 = 1,8d

f_2 = 3,1d

g_1 = 0,2d

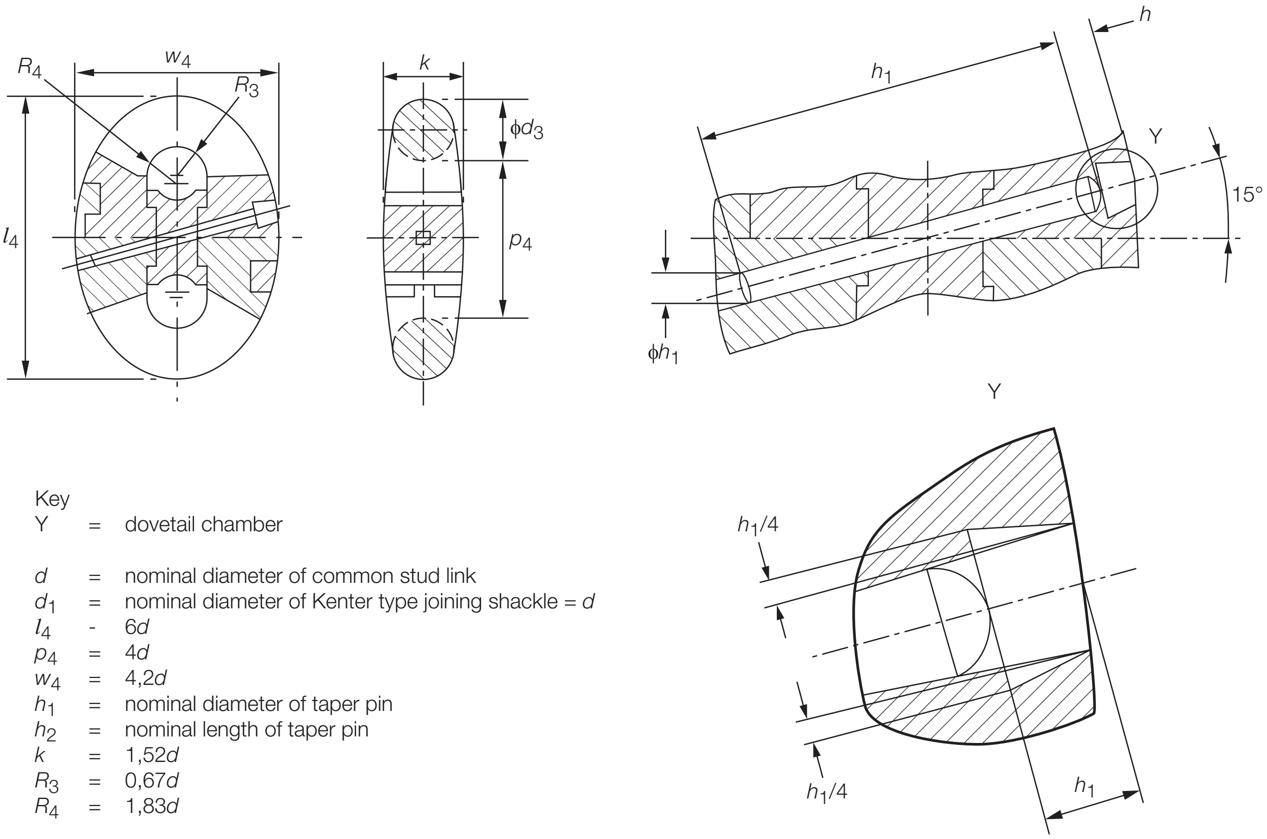
g_2 = 0,1d

m = 1,4d

h_1 = nominal diameter of taper pin

h_2 = nominal length of taper pin

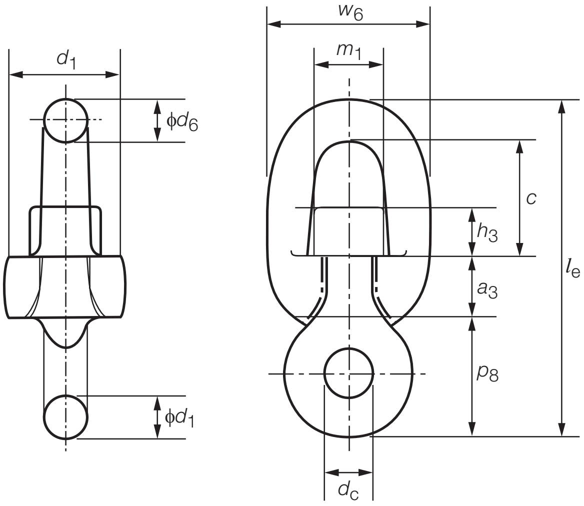
Fig. 10.2.5 Dee shackle



Key
Y = dovetail chamber

d = nominal diameter of common stud link
d_1 = nominal diameter of Kenter type joining shackle = d
l_4 - $6d$
p_4 = $4d$
w_4 = $4{,}2d$
h_1 = nominal diameter of taper pin
h_2 = nominal length of taper pin
k = $1{,}52d$
R_3 = $0{,}67d$
R_4 = $1{,}83d$

Fig. 10.2.6 Lugless shackle



d = nominal diameter of common stud link
d_6 = nominal diameter of swivel = $1{,}2d$
l_e = $9{,}7d$
p_e = $d_g - 3{,}4d$
w_6 = $4{,}7d$
d_7 = $1{,}1d$
a_3 = $1{,}76d$
m_1 = $2d$
h_3 = $d_g - 1{,}4d$
c = $3{,}35d$

Fig. 10.2.7 Swivel

2.16 Identification

2.16.1 All lengths of Grades U1, U2 and U3 cable and all fittings are to be stamped with the following identification marks:

(a) LR or Lloyd's Register and abbreviated name of LR's local office issuing the certificate.
(b) Number of certificate.
(c) Proof load and grade of chain.
(d) Surveyor's personal stamp.
(e) Each length of chain cable is to be stamped on both ends.

2.17 Certification

2.17.1 ~~Certificates may~~ An LR certificate is to be issued for chain cable only, fittings only or chain cable with associated fittings.

(*Part only shown*)
2.17.2 ~~The~~ Each test certificate is to include the following particulars for all items included on the certificate:

■ *Section 3*

Stud link mooring chain cables

3.1 Scope

3.1.1 Provision is made in this Section for ~~three~~ five grades, R3, R3S~~ and R4~~ , R4, R4S and R5, of stud link chain intended for offshore mooring applications such as mooring of mobile offshore units, offshore loading systems and gravity based structures during fabrication.

3.2 Manufacture

~~*3.2.4* Drawings showing the detailed design of the chain and accessories made by or supplied through the chain manufacturer are to be submitted for approval. These are to include details showing the design of the studs.~~

Existing paragraphs 3.2.5 *to* 3.2.7 *have been renumbered* 3.2.4 *to* 3.2.6.

~~*3.2.8*~~ *3.2.7* The following welding parameters (as approved in the weld procedure) are to be controlled during welding of each link:

(a) platen ~~motion,~~ motion;
(b) current as a function of ~~time.~~ time; and
(c) hydraulic pressure.

The controls are to be checked at least once every four hours.

Existing paragraphs 3.2.9 *and* 3.2.10 *have been renumbered* 3.2.8 *and* 3.2.9.

~~*3.2.11* Dimensions and tolerances are to comply with 2.15.~~

3.3 Dimensions and tolerances

3.3.1 The form and proportions of links and shackles are to be in accordance with ISO/1704-2008, *see* Figs. 10.2.1 to 10.2.8. Design of chain cables must be to a recognised standard, such as ISO 1704; alternatively the design may be specifically approved by LR. Link tolerances are to be in accordance with 3.3.2 to 3.3.6.

3.3.2 Diameter measured at the crown:

Minus 1 mm when $d_c \le 40$ mm
Minus 2 mm when 40 mm $< d_c \le 84$ mm
Minus 3 mm when 84 mm $< d_c \le 122$ mm
Minus 4 mm when 122 mm $< d_c \le 152$ mm
Minus 6 mm when 152 mm $< d_c \le 184$ mm
Minus 7,5 mm when 184 mm $< d_c \le 210$ mm

The plus tolerance must not exceed 5 per cent of the nominal diameter, and the cross-sectional area at the crown is to have no negative tolerance.

3.3.3 The diameter measured at locations other than the crown is to have no negative tolerance. The plus tolerance is to be in accordance with Table 3.9.3 except at the butt weld where it is to be in accordance with the manufacturer's specification, which is to be agreed by LR.

3.3.4 The maximum allowable tolerance on a length of five links measured in accordance with 2.12.1 is +2,5 per cent. No under-tolerance is permitted.

3.3.5 A manufacturing tolerance on all other dimensions of ±2,5 per cent is acceptable subject to all parts fitting properly together.

3.3.6 The tolerances for common links are to be measured in accordance with Fig. 10.3.3.

3.3.7 All measurements are to be made on links selected by the Surveyor and are to be carried out to the Surveyor's satisfaction.

3.3.8 Studs are to be located in the links centrally, and at right angles to the sides of the link, although the studs of the final link at each end of any length may also be located off-centre to facilitate the insertion of the joining shackle. The tolerances in accordance with Fig. 10.3.2 are acceptable provided that the stud fits snugly and its ends lie flush against the inside of the link.

~~3.3~~ 3.4 Studs

~~*3.3.1*~~ *3.4.1* The studs are to be made of steel corresponding to that of the chain or in compliance with a specification approved by LR. In general, the carbon content should not exceed 0,23 per cent if the studs are to be welded in place.

~~*3.3.2*~~ *3.4.2* Studs may be welded into grade R3 and R3S chains. The welding of studs into grade R4, R4S and R5 chain is not permitted unless ~~especially~~ specially approved.

~~*3.3.3*~~ *3.4.3* In all cases where studs are welded into links, this is to be carried out in accordance with ~~2.6~~ 2.7.

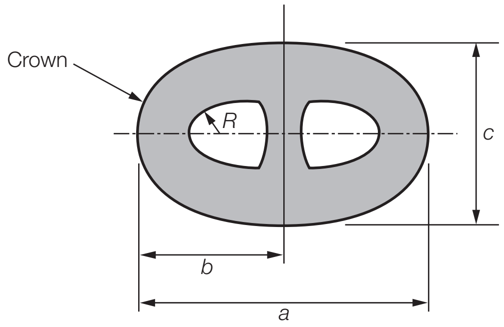
~~*3.3.4*~~ *3.4.4* The size of the stud welds is to be in accordance with Fig. 10.3.1.

~~*3.3.5*~~ *3.4.5* All stud welds are to be visually inspected. At least 10 per cent of all stud welds within ~~a 100 m~~ each length of chain are to be examined by ~~dye penetrant or~~ magnetic particle inspection after proof load testing. Stress raising defects such as cracks, ~~Cracks or~~ lack of fusion, gross porosity, and undercuts exceeding 1 mm are not ~~acceptable~~ permitted; if any such defects are found, then all stud welds in that ~~100 m~~ length of chain are to be examined by means of ~~dye penetrant or~~ magnetic particle inspection.

~~*3.3.6*~~ *3.4.6* Where plastic straining is used to set studs, the applied load is not to be greater than that qualified in approval tests. The combined effect of shape and depth of the impression of the stud in the link is not to cause any harmful notch effect or stress concentration.

Fig. 10.3.2 Stud link tolerances

The internal link radii (*R*) and external radii should be uniform



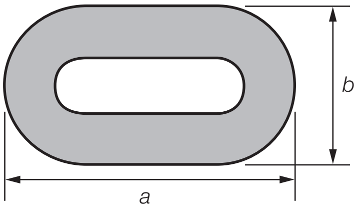
Designation	Description	Nominal dimension of the link	Minus tolerance	Plus tolerance
a	Link length	6*d*	0,15*d*	0,15*d*
b	Link half length	*a**/2	0,10*d*	0,10*d*
c	Link width	3,6*d*	0,09*d*	0,09*d*
e	Stud angular misalignment	0 degrees	4 degrees	4 degrees
R	Inner radius	0,65*d*	0	–

Symbols

d = nominal diameter of chain
*a** = actual link length

Fig. 10.3.3 Studless and common link tolerances

The internal link radii (*R*) and external radii should be uniform



Designation	Description	Nominal dimension of the link	Minus tolerance	Plus tolerance
a	Link length	6*d*	0,15*d*	0,15*d*
b	Link width	3,35*d*	0,09*d*	0,09*d*
R	Inner radius	0,60*d*	0	–

Symbols

d = nominal diameter of chain

NOTE
Other dimensional ratios are subject to special approval.

~~3.4~~ 3.5 Heat treatment of completed chain cables

Existing paragraphs 3.4.1 *and* 3.4.2 *have been renumbered* 3.5.1 *and* 3.5.2.

~~*3.4.3*~~ *3.5.3* The temperature and time, or temperature and chain speed, are to be controlled and continuously recorded.

Existing paragraphs 3.4.4 *and* 3.4.5 *have been renumbered* 3.5.4 *and* 3.5.5.

~~3.5~~ 3.6 Testing of completed chain cables

3.6.1 All chain cables are to be tested in the presence of a Surveyor, at a proving establishment recognised by LR. A list of recognised proving establishments is published by LR. In addition to the requirements stated in this Chapter, attention must be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

Existing paragraphs 3.5.1 *and* 3.5.2 *have been renumbered* 3.6.2 *and* 3.6.3.

~~3.5.3~~ 3.6.4 The chain is to be shot or sand blasted prior to testing in order to ensure that its surfaces are free from scale, paint or other coating for inspection. ~~This may be immediately before or after proof loading at the discretion of the manufacturers.~~

Existing paragraph 3.5.4 *has been renumbered* 3.6.5.

~~3.5.5~~ 3.6.6 All flash butt welds, including the area gripped by the clamping dies, are to be examined by magnetic particle inspection. The area is to be free from cracks, lack of ~~fusion and~~ fusion, gross porosity and any other stress concentrations.

Existing paragraphs 3.5.6 *and* 3.5.7 *have been renumbered* 3.6.7 *and* 3.6.8.

3.6.9 All non-destructive examination is to be carried out in accordance with approved procedures, in accordance with Ch 1,5.

3.6.10 All non-destructive examination operators are to be qualified to a minimum Level II, qualified in accordance with a recognised standard.

~~3.5.8~~ 3.6.11 After proof testing, the entire chain is to be checked for length, five links at a time with an overlap of two links, which is to include the first five links, to ensure that the chain meets the tolerances given in 2.15.5. The measurements are to be made while the chain is loaded to about 10 per cent of the proof load.

Existing paragraph 3.5.9 *has been renumbered* 3.6.12.

~~3.5.10~~ 3.6.13 If the length over five links is less than the nominal, the chain may be stretched by loading above the specified proof test load provided that the applied load is not greater than ~~that approved~~ ten per cent above the proof test load, and that only random lengths of the chain need to be stretched.

3.6.14 Loads used for plastic straining to set studs are not to exceed those approved in qualification tests.

Existing paragraph 3.5.11 *has been renumbered* 3.6.15.

~~3.5.12~~ 3.6.16 If any link fails to meet the dimensional tolerance requirements (*see* ~~2.15~~ 3.3), measurements are to be made on 20 more links on each side of the incorrect one. If failure to meet any particular dimensional requirements occurs in more than two of the measured links, then all the links are to be dimensionally checked.

~~3.5.13~~ 3.6.17 Should any link be found to be defective or fail to meet the dimensional tolerance requirements or if a five link length of chain exceeds the specified tolerance, the unsatisfactory links are to be removed from the chain, and connecting common links complying with the requirements of ~~3.6~~ 3.7 inserted in their places.

Existing paragraphs 3.5.14 *and* 3.5.15 *have been renumbered* 3.6.18 *and* 3.6.19.

~~3.5.16~~ 3.6.20 If a link breaks during proof load testing, a sample consisting of three common links is to be taken from each side of the broken link and subjected to a breaking test as detailed in ~~3.5.17~~ 3.6.21 and ~~3.5.18~~ 3.6.22. If either of these samples fails, the proof loaded length of cable is not to be accepted. A thorough examination of all broken links is to be made to determine the cause of failure and, after evaluation, LR will consider the extent of cable which is to be rejected and also the possibility that similar factors to those which caused the failure may also be present in other parts of the cable, or other chain cables. The Surveyor is to be advised in advance of all examinations, with reasonable notice being given.

~~3.5.17~~ 3.6.21 In addition to the requirements of ~~3.5.1~~ 3.6.2, three link samples are to be selected by the Surveyors from the completed chain for breaking tests. The number of tests required is to be in accordance with Table 10.3.2. Extra links are to be provided for the mechanical tests detailed in ~~3.5.21~~ 3.6.25. All test links are to be made as part of the chain cable and are to be heat treated with it. These may be removed from the cable prior to heat treatment provided that each sample is heat treated with, and in the same manner as, the chain it represents and is subjected to the proof load appropriate to the chain grade and diameter prior to selection of the mechanical test specimens. They are to be properly identified with the length of chain they represent.

Existing paragraphs 3.5.18 *to* 3.5.20 *have been renumbered* 3.6.22 *to* 3.6.24.

~~3.5.21~~ 3.6.25 One tensile and three sets of Charpy V-notch impact test specimens are to be taken from links cut from the heat treated and proof loaded chain at intervals no greater than those indicated in Table 10.3.2 provided that every cast is sampled. The tensile specimen and one set of impact specimens are to be taken from the side of the link opposite the weld. One set of impact test specimens is to have the notches positioned at the centre of the flash butt weld and the third set is to be taken from the bend. All the specimens are to be taken from positions in accordance with ~~Fig. 3.1.1(f) in Chapter 3~~ Fig. 10.3.4.

Existing paragraphs 3.5.22 *to* 3.5.25 *have been renumbered* 3.6.26 *to* 3.6.29.

3.6.30 The mass per unit length of stud link mooring cable is to comply with Table 10.3.4.

~~**Table 10.3.1 Test loads for mooring chain cables**~~

Chain diameter mm	Grade R3			Grade R3S			Grade R4		
	Proof test load		Break test load kN	Proof test load		Break test load kN	Proof test load		Break test load kN
	Stud link chain kN	Studless chain kN		Stud link chain kN	Studless chain kN		Stud link chain kN	Studless chain kN	
50	1480	1560	2230	1800	1740	2490	2160	1920	2740
52	1590	1680	2400	1940	1880	2680	2330	2070	2960
54	1710	1810	2580	2080	2020	2880	2500	2220	3170
56	1830	1940	2760	2230	2160	3090	2680	2380	3400
58	1960	2070	2950	2380	2310	3300	2860	2540	3630
60	2090	2200	3150	2540	2460	3510	3050	2710	3870
62	2220	2340	3350	2700	2620	3740	3240	2880	4110
64	2360	2490	3550	2870	2780	3970	3440	3050	4360
66	2500	2630	3760	3040	2940	4200	3640	3240	4620
68	2640	2780	3980	3210	3110	4440	3850	3420	4890
70	2790	2940	4200	3390	3280	4690	4060	3610	5160
73	3010	3170	4540	3660	3540	5060	4390	3900	5570
76	3240	3420	4880	3940	3820	5450	4730	4200	6000
78	3400	3590	5120	4140	4000	5720	4960	4410	6300
81	3640	3840	5490	4430	4290	6130	5320	4720	6750
84	3890	4110	5870	4740	4590	6550	5680	5050	7210
87	4150	4380	6250	5050	4890	6980	6060	5380	7680
90	4410	4650	6650	5370	5200	7420	6440	5720	8170
92	4590	4840	6920	5580	5410	7720	6700	5950	8500
95	4860	5130	7330	5910	5730	8180	7100	6300	9000
97	5050	5320	7600	6140	5940	8490	7370	6540	9340
100	5330	5620	8030	6480	6280	8960	7780	6910	9860
102	5520	5820	8320	6710	6500	9290	8050	7150	10220
105	5810	6130	8750	7070	6840	9770	8480	7530	10750
107	6010	6330	9050	7300	7070	10100	8760	7780	11120
111	6400	6760	9650	7790	7540	10780	9350	8300	11860
114	6710	7080	10110	8160	7900	11290	9790	8690	12420
117	7020	7400	10570	8540	8270	11810	10240	9100	12990
120	7330	7730	11050	8920	8630	12330	10700	9500	13570
122	7540	7960	11370	9170	8880	12690	11010	9780	13960
124	7750	8180	11690	9430	9130	13050	11320	10050	14360
127	8080	8520	12170	9820	9510	13590	11790	10470	14960
130	8400	8860	12660	10220	9900	14140	12270	10890	15560
132	8620	9100	12990	10490	10160	14510	12590	11180	15970
137	9180	9680	13830	11160	10810	15440	13400	11890	16990
142	9740	10270	14680	11850	11470	16390	14220	12620	18030
147	10310	10880	15540	12540	12140	17350	15050	13360	19090
152	10890	11480	16410	13240	12820	18320	15890	14110	20160
157	11470	12100	17280	13950	13510	19300	16740	14860	21230
162	12060	12720	18170	14660	14200	20280	17600	15620	22320

Table 10.3.1 Test loads for mooring chain cables *(continued)*

Nominal diameter *d*	Grade R3			Grade R3S			Grade R4			Grade R4S			Grade R5		
	Proof test load		Break test load	Proof test load		Break test load	Proof test load		Break test load	Proof test load		Break test load	Proof test load		Break test load
	Stud link chain	Studless chain		Stud link chain	Studless chain		Stud link chain	Studless chain		Stud link chain	Studless chain		Stud link chain	Studless chain	
mm	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
50	1480	1480	2230	1800	1740	2490	2160	1920	2740	2400	2130	3040	2510	2230	3200
52	1594	1594	2402	1939	1874	2682	2327	2068	2952	2585	2295	3275	2704	2402	3447
54	1712	1712	2580	2083	2013	2881	2499	2222	3170	2777	2465	3517	2904	2580	3703
56	1834	1834	2764	2231	2156	3086	2677	2380	3396	2974	2640	3768	3111	2764	3966
58	1960	1960	2953	2383	2304	3297	2860	2542	3628	3178	2820	4025	3323	2953	4237
60	2089	2089	3147	2540	2455	3514	3048	2710	3867	3387	3006	4290	3542	3147	4516
62	2221	2221	3347	2701	2611	3737	3242	2881	4112	3602	3196	4562	3767	3347	4802
64	2357	2357	3551	2867	2771	3965	3440	3058	4364	3822	3392	4841	3997	3551	5096
66	2496	2496	3761	3036	2935	4200	3643	3238	4621	4048	3593	5127	4233	3761	5397
68	2639	2639	3976	3209	3102	4440	3851	3423	4885	4279	3798	5420	4475	3976	5706
70	2785	2785	4196	3387	3274	4685	4064	3613	5156	4516	4008	5720	4723	4196	6021
73	3010	3010	4535	3660	3538	5064	4392	3904	5572	4881	4331	6182	5104	4535	6507
76	3242	3242	4884	3942	3811	5454	4731	4205	6001	5257	4665	6658	5498	4884	7009
78	3400	3400	5123	4135	3997	5720	4962	4411	6295	5514	4893	6984	5766	5123	7351
81	3643	3643	5490	4431	4283	6130	5317	4726	6745	5908	5243	7484	6179	5490	7877
84	3893	3893	5866	4735	4577	6550	5682	5051	7208	6313	5603	7997	6602	5866	8418
87	4149	4149	6252	5046	4878	6981	6056	5383	7682	6729	5972	8523	7037	6252	8971
90	4412	4412	6647	5365	5187	7422	6439	5723	8167	7154	6349	9062	7482	6647	9539
92	4590	4590	6916	5582	5396	7722	6699	5954	8497	7443	6606	9428	7784	6916	9924
95	4862	4862	7326	5913	5716	8180	7096	6307	9001	7884	6997	9987	8246	7326	10512
97	5047	5047	7604	6138	5933	8490	7365	6547	9343	8184	7263	10366	8559	7604	10911
100	5328	5328	8028	6480	6264	8964	7776	6912	9864	8640	7668	10944	9036	8028	11520
102	5519	5519	8315	6712	6488	9285	8054	7159	10217	8949	7942	11336	9359	8315	11932
105	5809	5809	8753	7065	6829	9773	8478	7536	10754	9420	8360	11932	9851	8753	12560
107	6005	6005	9048	7304	7060	10103	8764	7790	11118	9738	8643	12335	10184	9048	12984
111	6404	6404	9650	7789	7529	10775	9347	8308	11856	10385	9217	13154	10861	9650	13847
114	6709	6709	10109	8159	7887	11287	9791	8703	12420	10879	9655	13780	11378	10109	14506
117	7018	7018	10574	8535	8251	11807	10242	9104	12993	11380	10100	14415	11902	10574	15174
120	7331	7331	11047	8916	8619	12334	10700	9511	13573	11889	10551	15059	12434	11047	15852
122	7542	7542	11365	9173	8868	12690	11008	9785	13964	12231	10855	15493	12792	11365	16308
124	7755	7755	11686	9432	9118	13048	11319	10061	14358	12576	11161	15930	13153	11686	16768
127	8078	8078	12171	9824	9497	13591	11789	10479	14955	13099	11626	16592	13700	12171	17466
130	8404	8404	12663	10221	9880	14139	12265	10903	15559	13628	12095	17262	14253	12663	18171
132	8623	8623	12993	10488	10138	14508	12585	11187	15965	13984	12411	17713	14625	12993	18645
137	9178	9178	13829	11162	10790	15441	13395	11906	16992	14883	13209	18852	15565	13829	19844

Table 10.3.1 Test loads for mooring chain cables (*conclusion*)

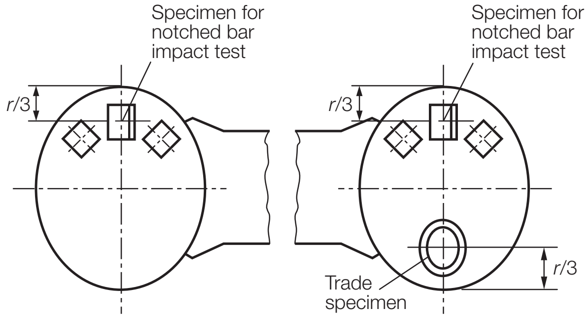
Nominal diameter d	Grade R3			Grade R3S			Grade R4			Grade R4S			Grade R5		
	Proof test load		Break test load	Proof test load		Break test load	Proof test load		Break test load	Proof test load		Break test load	Proof test load		Break test load
	Stud link chain	Studless chain		Stud link chain	Studless chain		Stud link chain	Studless chain		Stud link chain	Studless chain		Stud link chain	Studless chain	
mm	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
142	9741	9741	14677	11847	11452	16388	14216	12637	18033	15796	14019	20008	16520	14677	21061
147	10311	10311	15536	12540	12122	17347	15048	13376	19089	16720	14839	21179	17487	15536	22294
152	10887	10887	16405	13241	12800	18317	15890	14124	20156	17655	15669	22363	18464	16405	23540
157	11469	11469	17282	13949	13484	19297	16739	14879	21234	18599	16507	23559	19452	17282	24799
162	12056	12056	18166	14663	14174	20284	17596	15641	22320	19551	17351	24764	20447	18166	26068
167	12647	12647	19056	15381	14869	21278	18458	16407	23414	20508	18201	25977	21448	19056	27345
172	13240	13240	19950	16103	15566	22276	19324	17177	24513	21471	19055	27196	22455	19950	28628
177	13836	13836	20847	16827	16267	23278	20193	17949	25615	22437	19912	28420	23465	20847	29915
182	14433	14433	21746	17553	16968	24282	21064	18723	26720	23404	20771	29645	24477	21746	31205
187	15029	15029	22646	18279	17670	25286	21935	19498	27825	24372	21630	30871	25489	22646	32496
192	15626	15626	23544	19004	18371	26289	22805	20271	28929	25339	22488	32096	26500	23544	33785
197	16220	16220	24440	19727	19070	27290	23673	21043	30029	26303	23344	33317	27509	24440	35071
202	16813	16813	25332	20448	19766	28286	24537	21811	31126	27264	24196	34534	28513	25332	36351
207	17401	17401	26220	21164	20459	29277	25397	22575	32216	28219	25044	35744	29512	26220	37625
210	17753	17753	26749	21591	20872	29868	25910	23031	32867	28788	25550	36465	30108	26749	38385

Grade R3		
Proof test load	Stud link chain	0,0148d^2 (44 – 0,08d)
	Studless chain	0,0148d^2 (44 – 0,08d)
Break test load		0,0223d^2 (44 – 0,08d)
Grade R3S		
Proof test load	Stud link chain	0.0180d^2 (44 – 0,08d)
	Studless chain	0,0174d^2 (44 – 0,08d)
Break test load		0,0249d^2 (44 – 0,08d)
Grade R4		
Proof test load	Stud link chain	0,0216d^2 (44 – 0,08d)
	Studless chain	0,0192d^2 (44 – 0,08d)
Break test load		0,0274d^2 (44 – 0,08d_c)
Grade R4S		
Proof test load	Stud link chain	0,0240d^2 (44 – 0,08d)
	Studless chain	0,0213d^2 (44 – 0,08d)
Break test load		0,0304d^2 (44 – 0,08d)
Grade R5		
Proof test load	Stud link chain	0,0251d^2 (44 – 0,08d)
	Studless chain	0,0223d^2 (44 – 0,08d)
Break test load		0,0320d^2 (44 – 0,08d)

Table 10.3.2 Frequency of break and mechanical tests

Nominal chain diameter mm	Maximum sampling interval m (*See* Note)
Min. — 48	91
49 — 60	110
61 — 73	131
74 — 85	152
86 — 98	175
99 — 111	198
112 — 124	222
125 — 137	250
138 — 149	274
150 — 162	297
163 — 175	322
176 — 186	346
187 — 199	370
199 — 210	395

NOTE
If the sampling interval contains links made from more than one cast, extra break and mechanical tests are required so that tests are made on every cast.


Specimen for notched bar impact test
Specimen for notched bar impact test
r/3
r/3
r/3
Trade specimen

r = specimen radius

Fig. 10.3.4 Sampling of chain links

Table 10.3.3 Mechanical properties of chain cable materials

Grade	Yield stress N/mm^2 minimum	Tensile strength N/mm^2	Elongation % minimum	Reduction of area % minimum (*See* Note 3)	Charpy V-notch impact tests: Test temperature °C	Charpy V-notch impact tests: Average energy J minimum	Charpy V-notch impact tests: Average energy flash weld J minimum
R3	410 (*See* Note 1)	690 minimum (*See* Note 1)	17	50	0 –20 (*See* Note 2)	60 40	50 30
R3S	490 (*See* Note 1)	770 minimum (*See* Note 1)	15	50	0 –20 (*See* Note 2)	65 45	53 33
R4	580 (*See* Note 1)	860 minimum (*See* Note 1)	12	50	–20	50	36
R4S (*See* Note 4)	700 (*See* Note 1)	960 (*See* Note 1)	12	50	–20	56	40
R5 (*See* Note 4)	760 (*See* Note 1)	1000 (*See* Note 1)	12	50	–20	58	42

NOTES
1. The ratio of yield strength to tensile strength should not exceed 0,92.
2. Testing may be carried out at either 0°C or –20°C.
3. For cast ~~accessories~~ fittings, the minimum values for reduction of area are to be 40% for Grades R3 and R3S and 35% for ~~Grade R4~~ Grades R4, R4S and R5.
4. The maximum hardness for Grade R4S is to be HB330, and for Grade R5 is to be HB340.

Table 10.3.4 Mass per unit length of chain cable

Nominal chain diameter (mm)	Mass per unit length $0{,}0291d^2$ (kg/m)
50	73
55	88
60	105
65	123
70	143
75	164
80	186
85	210
90	236
95	263
100	291
105	321
110	352
115	385
120	419
125	455
130	492
135	530
140	570
145	612
150	655
155	699
160	745
165	792
170	841
175	891
180	943
185	996
190	1051
195	1107
200	1164
205	1223
210	1283

~~3.6~~ 3.7 Connecting common links or substitute links

~~3.6.7~~ 3.7.7 Every connecting common link is to be inspected in accordance with ~~3.5.4 to 3.5.7~~ 3.6.5 to 3.6.10.

~~3.6.8~~ 3.7.8 A second identical link is to be made for mechanical tests which are to be in accordance with ~~3.5.21~~ 3.6.25. This test link is also to be inspected in accordance with ~~3.6.7~~ 3.7.7.

~~3.6.9~~ 3.7.9 Each connecting common link is to be stamped on the stud with the identification marks listed in ~~3.8.1~~ 3.9.1 plus a unique number for the link. The adjoining links are also to be stamped on the studs.

~~3.7~~ 3.8 Fittings for offshore mooring chain

~~3.7.1~~ 3.8.1 Cable fittings are to be manufactured at an approved works. Fittings include, but are not limited to, shackles, triplates, end shackles, swivels, and swivel shackles.

~~3.7.2~~ 3.8.2 The materials from which the fittings are made are to be manufactured at approved works, in accordance with the appropriate requirements of Ch 4,1 or Ch 5,1, and 3.8.3 to 3.8.6. Alternative arrangements may be agreed provided that full details concerning the manufacturer are submitted to LR.

3.8.3 Steel used for fittings must be manufactured by an approved process, and be killed and fine grain treated.

3.8.4 The austenite grain size of steel used for fittings must be 6 or finer as measured in accordance with ASTM E112.

3.8.5 Steel used for forgings or castings for grades R4S and R5 must be vacuum degassed.

3.8.6 For steel used for forgings or castings for grades R4S and R5 the following tests are to be carried out on each heat:

(a) Assessment and quantification of the level of non-metallic micro inclusions. These must be acceptable for the final product.

(b) Macro etching on representative sample, in accordance with ASTM E381 or equivalent, this must be free from any injurious segregation or porosity.

(c) Jominy hardenability tests in accordance with ASTM A255 or equivalent.

The results of these tests are to be supplied by the steel manufacturer, and the results are to be included in the final accessory documentation.

3.8.7 Fittings for chain are to be heat treated in accordance with procedures that have been approved by LR.

~~3.7.3~~ 3.8.8 All fittings are to be manufactured to a manufacturing specification approved by LR, and provision is to be made for tensile and impact test specimens. The test samples are to be subjected to heat treatment with the fittings they represent. The mechanical test requirements are the same as those for the relevant grade of chain cable, *see* Table 10.3.3~~, except that for castings the minimum required Reduction of Area is 40 per cent for Grades R3 and R3S and 35 per cent for Grade R4~~.

3.8.9 A batch is defined as fittings from the same heat of steel that have been part of the same heat treatment charge.

3.8.10 Mechanical tests for fittings are to be taken from full size fittings that have been heat treated with the production batch they represent, and the tests are to be taken after the fitting has been proof load tested. It is not permitted to use separate representative coupons unless approved by LR in accordance with 3.8.14.

3.8.11 Forged shackle bodies and forged Kenter shackles are to have a set of three Charpy impact tests and a tensile test taken from the crown of the shackle. For smaller diameter shackles, where the geometry does not allow for the tensile test to be taken from the crown, this may be taken from the straight portion from the locations specified in Fig. 10.3.5, with the Charpy impact test specimens on the outside radius.

3.8.12 The test pieces for cast shackle bodies and cast Kenter shackles can be taken from the straight portion of the fitting from the locations shown in Fig. 10.3.5.

3.8.13 For fittings with complex geometries the locations of test pieces taken are to be approved by LR.

3.8.14 Where fittings are produced in small batches (less than 5) alternative testing may be approved; a proposal must be submitted in a written procedure for consideration.

3.8.15 Mechanical tests of pins are to be taken as shown in Fig. 10.3.6 from the mid length of a sacrificial pin of the same diameter as the final pin. For oval pins, the diameter taken is to represent the smaller dimension. Mechanical tests may be taken from an extended pin of the same diameter as the final pin that incorporates a test prolongation and a heat treatment buffer prolongation, where equivalence with mid length test values have been established. The length of the buffer is to be at least equal to 1 pin diameter which is removed after the heat treatment cycle is finished. The test coupon can then be removed from the pin. The buffer and test are to come from the same end of the pin, as shown in Fig. 10.3.6.

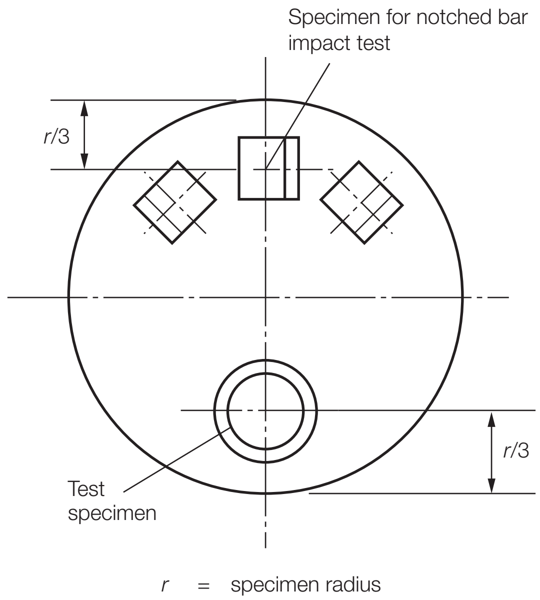


Fig. 10.3.5
Sampling of steel bars, forgings and castings

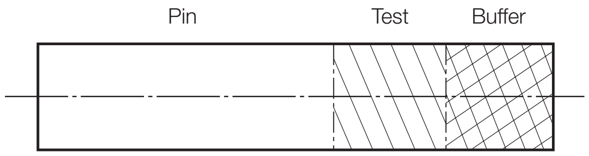


Fig. 10.3.6
Buffer and test piece location for pins

Existing paragraphs 3.7.4 *and* 3.7.5 *have been renumbered* 3.8.16 *and* 3.8.17.

~~*3.7.6* The proof load test is to be carried out in the presence of the Surveyor but if the manufacturer has a procedure for recording proof loads and the Surveyor is satisfied with the adequacy of the recording system, he need not witness all proof load tests.~~

~~*3.7.7*~~ *3.8.18* The appropriate breaking load as required by Table 10.3.1 is to be applied to at least one item out of every batch of up to 25, and this item is to be destroyed and not used as part of an outfit. ~~A batch of accessories is to be of the same grade, size and heat treatment charge and to have originated from a single cast of steel.~~

~~*3.7.8*~~ *3.8.19* If the sample fails to withstand the breaking load without fracture, or in the event of failure of any other test, then the entire batch is to be rejected unless the cause of failure has been determined and it can be demonstrated that the condition causing failure is not present in any of the other accessories in the batch. If this can be demonstrated then two more samples from the same batch may be tested. If either of these samples fails, the batch is to be rejected.

~~*3.7.9*~~ *3.8.20* For very large fittings where the required breaking load is greater than the capacity of the testing machine and for individually produced accessories or accessories produced in small batches, proposals for an alternative method of testing will be given special consideration. All proposals for alternative testing methods are to be detailed in writing and submitted.

~~*3.7.10*~~ *3.8.21* At least one accessory from each batch is to be checked dimensionally after proof load testing. The manufacturer is to provide a statement that the dimensions comply with the specified requirements.

3.8.22 The following tolerances apply of the unmachined dimensions of all fittings;
(a) nominal diameter plus 5 per cent, minus 0 per cent; and
(b) other dimensions plus or minus 2,5 per cent.

~~*3.7.11*~~ *3.8.23* All accessories are to be subjected to close visual examination after proof load testing, particular attention being paid to machined surfaces and highly stressed regions. All accessories are also to be examined by magnetic particle or dye penetrant inspection and ultrasonic testing. All NDE is to be carried out in accordance with 3.6.9 and 3.6.10. The manufacturer is to provide a statement that the non-destructive examination has been carried out with satisfactory results; this statement is to include reference to the techniques used and the operator's qualifications.

~~*3.7.12* In the event of a failure of any test, the entire batch is to be rejected unless the cause of failure has been determined and it can be demonstrated that the condition causing failure is not present in any of the other accessories in the batch.~~

~~*3.7.13*~~ *3.8.24* ~~Except as indicated in 3.7.6, all~~ All testing is to be carried out to the satisfaction and in the presence of the Surveyor.

3.8.25 Fittings with increased dimensions, or fittings of a higher material grade, may be specially approved and included in an outfit, provided that;

(a) each item is successfully tested at the required breaking load for the chain cable for which they are intended; and
(b) items of increased dimensions are so designed that their breaking strength is not less than 1,4 times the Rule minimum breaking load for the chain cable for which they are intended, and this has been verified by procedure tests.

~~3.8~~ 3.9 Identification

Existing paragraphs 3.8.1 *to* 3.8.3 *have been renumbered* 3.9.1 *to* 3.9.3.

~~3.9 Certification~~

~~*3.9.1* Individual certificates are to be issued for each continuous single length of chain.~~

~~*3.9.2* The test certificate is to include the following particulars:~~

~~(a) Purchaser's name and order number.~~
~~(b) Description and dimensions.~~
~~(c) Grade of chain cable.~~
~~(d) Identification mark which will enable the full history of the chain to be traced.~~
~~(e) Chemical composition.~~
~~(f) Details of heat treatment.~~
~~(g) Mechanical test results.~~
~~(h) Breaking test load.~~
~~(j) Proof load.~~
~~(k) The number and locations of all connecting common links and all marked links.~~

~~3.10 Documentation~~

~~*3.10.1* A complete Chain Inspection and Testing Report, in booklet form, is to be provided by the chain manufacturer for each continuous chain length. It is to include all dimensional checks, test and inspection reports, non-destructive test reports, process records as well as any non-conformities together with corrective action and repair work.~~

~~*3.10.2* All documents, including reports and appendices are to carry a reference to the relevant certificate number.~~

~~*3.10.3* The chain manufacturer is responsible for storing all the documentation in a safe and retrievable manner for a period of at least 10 years.~~

~~*3.10.4* An Inspection and Testing Report, in booklet form, is to be provided for each order. This is to include all reports of tests, inspections and dimensional measurements and all non-conformities together with corrective or repair action taken. Each type of accessory is to be covered by a separate certificate. All accompanying documents are to carry a reference to the relevant certificate number. The manufacturer is responsible for storing all documentation for a period of at least 10 years in a safe and retrievable manner.~~

3.10 Documentation

3.10.1 A complete Chain Inspection and Testing Report, in booklet form, is to be provided by the chain manufacturer for each continuous chain length, and for each order for chain and fittings. It is to include all dimensional checks, test and inspection reports, non-destructive test reports, process records, as well as any non-conformity, together with corrective action and repair work.

3.10.2 All documents, including reports and appendices, are to contain a reference to the relevant certificate number.

3.10.3 The chain manufacturer is responsible for storing all the documentation in a safe and retrievable manner for a period of at least 10 years.

3.11 Certification

3.11.1 An LR certificate is to be issued for each continuous single length of chain, and each type of fitting, *see* Ch 1,3.1.

3.11.2 Each test certificate is to include the following particulars:

(a) Purchaser's name and order number.
(b) Description and dimensions.
(c) Grade of chain cable.
(d) Identification mark which will enable the full history of the chain to be traced.
(e) Chemical composition.
(f) Details of heat treatment.
(g) Mechanical test results.
(h) Breaking test load.
(j) Proof load.
(k) The number and locations of all connecting common links and all marked links.

■ *Section 4*
Studless mooring chain cables

4.1 Scope

4.1.1 Provision is made in this Section for five ~~three~~ grades, R3, R3S~~ and R4~~, R4, R4S and R5 of studless flash butt welded chain cable intended for long term mooring applications.

4.1.3 Each studless chain link design will require to be approved by LR. The plan submitted for this approval is to include the minimum proof and breaking test loads, and the chain mass calculations.

4.4 Dimensional tolerances

4.4.1 The dimensional tolerances of studless links are to be in accordance with the requirements of ~~2.15.2 to 2.15.6~~ 3.3.1 to 3.3.7.

4.5 Heat treatment

4.5.1 Heat treatment of the chain is to be in accordance with the requirements of ~~3.4~~ 3.5.

4.6 Testing of completed chain

4.6.1 All chain cables are to be tested in the presence of a Surveyor, at a proving establishment recognised by LR. A list of recognised proving establishments is published by LR. In addition to the requirements stated in this Chapter, attention must be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

~~*4.6.1*~~ *4.6.2* The entire length of chain cable is to be subjected to a proof load test in an approved testing machine and is to withstand the load given in Table 10.3.1 for the appropriate grade and diameter of the chain, *see also* 4.1.3.

~~*4.6.2*~~ *4.6.3* Inspection after proof load testing is to be in accordance with the requirements given in ~~3.5.2 to 3.5.16~~ 3.6.3 to 3.6.20, excluding that related to checking of studs in 3.5.4.

~~*4.6.3*~~ *4.6.4* In addition to the inspection of the flash butt welded areas as required in ~~3.5.5~~ 3.6.6, the surfaces of the bends of at least 10 per cent of the links are to be examined by magnetic particle inspection and are to be free from cracks or other defects.

~~*4.6.4*~~ *4.6.5* If stretching of links is required in order to maintain dimensional tolerances ~~(see 3.5.10)~~, the load applied is not to exceed the proof load by more than 10 per cent, and only random lengths of the chain need to be stretched.

~~*4.6.5*~~ *4.6.6* Breaking load tests are to be carried out in accordance with ~~3.5.17 to 3.5.19~~ 3.6.21 to 3.6.23 and Tables 10.3.1 and 10.3.2.

~~*4.6.6*~~ *4.6.7* Alternative procedures to breaking load testing (*see* ~~3.5.20~~ 3.6.24) are not permissible unless prior agreement is given by LR after special consideration.

~~*4.6.7*~~ *4.6.8* Mechanical testing is to be carried out in accordance with ~~3.5.21 to 3.5.25~~ 3.6.25 to 3.6.30 and Table 3.3.3.

4.6.9 The weight of the chain cable is to be in accordance with the approved plan.

4.7 Connecting or substitute links

4.7.1 Connecting links and substitute links are to be in accordance with the requirements of ~~3.6~~ 3.7.

4.8 Fittings

4.8.1 Fittings for studless chain are to comply with the requirements of ~~3.7~~ 3.8.

4.9 Identification

4.9.1 All chain and each fitting is to be identified in accordance with ~~3.8.1 and 3.8.2~~ 3.9.1 and 3.9.2.

4.11 Documentation

4.11.1 Documentation in accordance with ~~3.10~~ 3.11 is to be provided by the manufacturer.

■ *Section 5*
Short link chain cables

5.1 Scope

5.1.2 Provision is made for ~~two~~ grade~~s, L(3) and~~ M(4), as defined in ISO 1834:1999. Allowance is also made for the requirements of ISO 4565.

5.4 Testing and inspection of chain cables

5.4.1 All chain cable of 12,5 mm diameter and above, and all steering chains, irrespective of diameter, are to be tested in the presence of a Surveyor at a proving establishment recognised by LR. A list of recognised proving establishments is published ~~separately~~ by LR. In addition to the requirements stated in this Chapter, attention is to be given to any relevant statutory requirements of the National Authority of the country in which the ship or other marine structure is to be registered.

5.6 Identification

5.6.1 All lengths of cable are to be stamped with the following identification marks:

(a) Inspector's mark and date.
(b) Reference mark or number of certificate.
(c) Manufacturer's mark or name.
(d) Chain cable quality mark, M, is to be stamped on at least each twentieth link or at intervals of one metre, whichever is the lesser distance.

~~Item (d), which shall be either L or M as appropriate, is to be stamped on at least each twentieth link or at intervals of one metre, whichever is the lesser distance.~~

~~Table 10.5.1~~ ~~Mechanical test requirements for~~ short link chain cables

Chain diameter mm	Grade L(3)		Grade M(4)	
	Proof load kN	Breaking load minimum kN	Proof load kN	Breaking load minimum kN
5	—	—	7,9	15,8
6	9	18	—	—
6,3	—	—	12,5	25
7,1	—	—	15,9	31,8
8	16	32	20,2	40,4
9	—	—	25,5	51
10	25	50	31,5	63
11,2	—	—	39,5	79
12	35,5	71	—	—
12,5	—	—	49,1	98,2
14	—	—	63	126
16	—	—	81	162
18	—	—	102	204
20	—	—	126	252
22,4	—	—	158	316
25	—	—	197	394
28	—	—	247	494
32	—	—	322	644
36	—	—	408	816
40	—	—	503	1006
45	—	—	637	1274

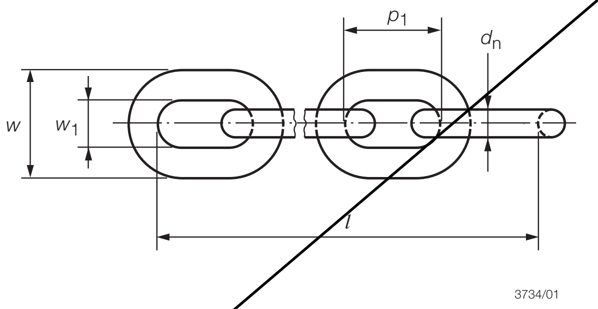
Table 10.5.1 Mechanical test requirements for short link chain cables

Chain diameter mm	Grade M(4)	
	Proof load kN	Breaking load minimum kN
5	7,9	15,8
6,3	12,5	25
7,1	15,9	31,8
8	20,2	40,4
9	25,5	51
10	29,5	63
11,2	31,5	79
12,5	49,1	98,2
14	63	126
16	81	162
18	102	204
20	126	252
22,4	158	316
25	197	394
28	247	494
32	322	644
36	408	816
40	503	1006
45	637	1274

5.7 Certification

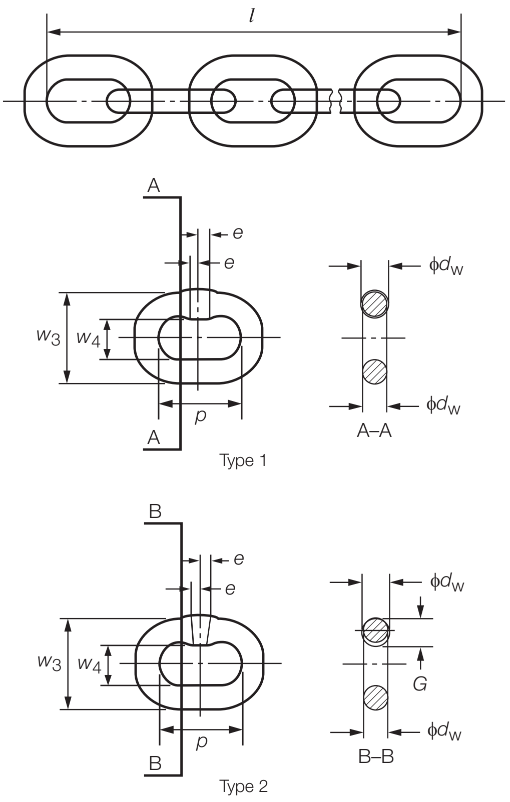
5.7.2 ~~The~~ Each test certificate is ~~also~~ to include the following particulars:

(a) the quality and description of chain,
(b) identification mark,
(c) nominal size of chain,
(d) proof load,
(e) breaking load,
(f) total elongation at fracture,
(g) where appropriate, the name of the proving establishment.



d_n = nominal diameter of link
l = length over which dimensional tolerances are measured = $11p_1$
p_1 = pitch of chain = $3d_n$
w = outside width = $3{,}6d_n$
w_1 = inside width = $1{,}35d_n$

Fig. 10.5.1 Form and proportions of links



l = multiple pitch length
p = pitch (internal link length)
d_n = measured diameter of the material, except at the weld
d_w = measured diameter of the material at the weld (Type 1) or weld dimension perpendicular to the plane of the link (Type 2)
G = dimension in other planes as per individual chain specification (Type 2)
e = length affected by welding, on either side of the centre link
w_1 = internal link width away from the weld
w_2 = external link width away from the weld
w_3 = external link width over the weld
w_4 = internal link width at the weld

Fig. 10.5.1 Form and proportions of links

■ *Section 6*
Steel wire ropes

6.7 Certification

~~*6.7.1* The manufacturer’s certificate may be accepted. The certificate is to be validated by the manufacturer’s representative, who is to be independent of the production process and LR.~~

6.7.1 A manufacturer’s certificate, in accordance with Ch1,3.1.3(c), is to be issued. The certificate is to be validated by the manufacturer’s representative, who is to be independent of the production process and LR.

■ *Section 7*
Fibre ropes

7.4 Certification

~~*7.4.1* Printed certificates issued by the manufacturer or a competent governmental, municipal or similar responsible body will be accepted. These certificates are to give the breaking load, test length and rate of straining.~~

7.4.1 A manufacturer’s certificate, in accordance with Ch1,3.1.3(c), is to be issued. The certificate is to be validated by the manufacturer’s representative, who is to be independent of the production process and LR.

7.4.2 Each test certificate is to include the following particulars:

- Manufacturer’s name.
- Purchaser’s name and order number.
- Rope type.
- Dimensions.
- Test length.
- Rate of straining.
- Breaking load.

Chapter 11
Approval of Welding Consumables

Effective date 1 July 2011

■ *Section 1*
General

1.8 Certification

1.8.1 Each carton or package of approved electrodes is to contain a certificate from the manufacturer, generally in accordance with the following: ‘The <*insert name of manufacturer*> company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the approval bodies nominated on the label of this package.’

■ *Section 3*
Electrodes for manual and gravity welding

~~3.10 Certification~~

~~*3.10.1* Each carton or package of approved electrodes is to contain a certificate from the manufacturer generally in accordance with the following:~~

> ~~‘The............................company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the approval bodies nominated on the label of this package.’~~

~~*3.10.2* Additionally, the manufacturer will be required to sign a similar declaration relating to continuing production.~~

~~3.11~~ 3.10 Annual tests

Existing paragraphs 3.11.1 *to* 3.11.5 *have been renumbered* 3.10.1 *to* 3.10.5.

■ *Section 8*
Consumables for welding austenitic and duplex stainless steels

8.5 Annual tests

8.5.1 Annual tests are to be carried out as required by the relevant Section appropriate to the type of consumable and welding technique. The tests are to include a weld ferrite content in accordance with 8.2.4 or 8.3.3 as appropriate.

Chapter 12
Welding Qualifications

Effective date 1 July 2011

■ *Section 2*
Welding Procedure Qualification Tests for Steels

2.5 Non-destructive examination (NDE)

2.5.5 All ~~NDE is~~ NDEs are to be carried out in accordance with the requirements of Ch 1,5. Assessment of results is to be in accordance with ISO 5817 Level B except for excess convexity and excess throat thickness where Level C will apply. Linear porosity is not permitted.

2.15 Range of approval

2.15.10 **Welding consumables**:

(a) For manual and semi-automatic welding used for the fill and capping weld runs, it may be acceptable to change the brand or trade name of the welding electrode or wire from that used in the test, provided the proposed alternative has the same or higher approval grading and the same flux type (e.g. basic low hydrogen, rutile, etc.) as used in that test.

(b) For the consumable used to make the root weld of full penetration butt welds made from one side only, no change in the type or trade name of the consumable or backing material is permitted. Alternative backing materials may be used provided they are equivalent to those used for approval. Where the approved backing material is a low hydrogen grade and the steel being welded requires a low hydrogen backing material, testing of the alternative backing material is to confirm compliance with the requirements of Ch 11,7.

(c) For processes with heat input over 5 kJ/mm, no change in the type or trade name of the consumable is permitted.

■ *Section 4*
Welding procedure tests for non-ferrous alloys

4.1 Requirements for aluminium alloys

4.1.2 Non-destructive examination is to be performed in accordance with 2.5 and the assessment of results is to be in accordance with Table 12.4.1 and Table 12.4.2.

~~Table 12.4.1 Non-destructive examination acceptance limits for aluminium alloys~~

Imperfection	Acceptance limits for aluminium alloys
Surface Profile	
Undercut	Slight intermittent, provided depth does not exceed 0,5 mm
Excess penetration and concavity	4,0 mm max.
Weld reinforcement height	7,0 mm max.
Asymmetry of fillet welds	Maximum difference between leg lengths = 20% of throat + 2 mm
Shrinkage groove or root concavity	Slight intermittent provided that it does not exceed 1,0 mm
Overlap	Not permitted
Reinforcement shape	The weld reinforcement is to blend smoothly with the parent material
Misalignment	t/10 but not greater than 2,5 mm
Cracking and lamellar tears	Not permitted
Lack of root fusion	Not permitted
Lack of side-wall fusion	Not permitted
Lack of inter-run fusion	Not permitted
Lack of penetration	Not permitted
Porosity	
Individual pores	d not greater than t/4 2,0 mm max.
Uniformly distributed	For t up to 6 mm d = 0,4 mm max. For t over 6 mm d = 0,8 mm max. pores between $0{,}8 < d < 1{,}6$ limited to t/2 in number per 100 mm^2 of weld area
Solid inclusions	
Slag inclusions - linear *see* Note 1	Not permitted
Oxide inclusions - linear	Widely scattered and each not exceeding 1,5 max.
Slag inclusions - individual	Not permitted
Metallic inclusions	Tungsten – 0,8 mm max. Copper – not permitted

where
t = material thickness
d = diameter of circular shaped imperfection

NOTES
1. Linear inclusions parallel to the weld may indicate lack of fusion or penetration and may require further investigation.
2. A planar defect is considered to have only two dimensions, i.e. no thickness. For example, cracks or lack of fusion.
3. A volumetric defect is one that is considered to have three dimensions, e.g. inclusions, porosity, etc.

Table 12.4.1 Acceptance criteria for surface imperfections of aluminium alloys

Surface discontinuity	Classification according to ISO 6520-1	Acceptance criteria
Crack	100	Not permitted
Lack of fusion	401	Not permitted
Incomplete root penetration in butt joints welded from one side	4021	Not permitted
Surface pore	2017	$d \leq 0{,}1s$ or $0{,}1a$ max. 1,0 mm
Uniformly distributed porosity (*see* Note 1)	2012	≤ 0,5% of area
Clustered porosity	2013	Not permitted
Continuous undercut	5011	Not permitted
Intermittent undercut	5012	$h \leq 0{,}1t$ or 0,5 mm (whichever is the lesser)
Excess weld metal (*see* Note 2)	502	$h \leq 1{,}5$ mm + $0{,}1b$ or 6 mm (whichever is the lesser)
Excess penetration	504	$h \leq 4$ mm
Root concavity (*see* Note 2)	515	$h \leq 0{,}05t$ or 0,5 mm (whichever is the lesser)
Linear misalignment (*see* Notes 3 and 4)	507	$h \leq 0{,}2t$ or 2,0 mm (whichever is the lesser)

Symbols

a = nominal throat thickness of a fillet weld
b = width of weld reinforcement
d = diameter of a gas pore
h = height or width of an imperfection
s = nominal butt weld thickness
t = wall or plate thickness (nominal size)

NOTES

1. To be in accordance with EN ISO 10042.
2. A smooth transition is required.
3. The limits for linear misalignment relate to deviations from the correct position. Unless otherwise specified, the correct position is to be taken when the centrelines coincide.
4. Dimensional tolerances not specified in these Rules are to be mutually agreed between the manufacturer and the Surveyor.

Table 12.4.2 Acceptance criteria for internal imperfections of aluminium alloys

Internal discontinuity	Classification according to ISO 6520-1	Acceptance criteria
Crack	100	Not permitted
Lack of fusion	401	Not permitted
Incomplete penetration	402	Not permitted
Single gas pore	2011	$d \le 0{,}2s$ or $0{,}2a$ or 4 mm (whichever is the lesser)
Linear porosity (*see* Note 2)	2014	Not permitted
Uniformly distributed porosity (*see* Note 2)	2012	$0{,}5t$ to $3t$ ≤ 1% of area $> 3t$ to $12t$ ≤ 2% of area $> 12t$ to $30t$ ≤ 3% of area $> 30t$ ≤ 4% of area
Clustered porosity (*see* Note 1)	2013	$dA \le 15$ mm or wp (whichever is the lesser)
Elongated cavity Wormhole	2015 2016	$l \le 0{,}2s$ or $0{,}2a$ or 3 mm (whichever is the lesser)
Oxide inclusion (*see* Note 2)	303	$l \le 0{,}2s$ or $0{,}2a$ or 3 mm (whichever is the lesser)
Tungsten inclusion	3041	$l \le 0{,}2s$ or $0{,}2a$ or 3 mm (whichever is the lesser)
Copper inclusion	3042	Not permitted
Multiple imperfections in any cross-section	—	The sum of the acceptable individual imperfections in any cross-section is not to exceed $0{,}2t$ or $0{,}2a$ (whichever is the lesser)

Symbols

a = nominal throat thickness of a fillet weld
d = diameter of a gas pore
h = height or width of an imperfection
s = nominal butt weld thickness
t = wall or plate thickness (nominal size), in mm
wp = width of weld or width or height of cross-sectional area
dA = diameter of area surrounding gas pores
l = length of imperfection in longitudinal direction of weld

NOTES
1. For this acceptance criterion, linear porosity is to be considered as three aligned gas pores in a length of 25 mm.
2. Porosity is to be determined in accordance with ISO 10042. The requirements for a single gas pore are to be met by all the gas pores within this circle. Systematic clustered porosity is not permitted.

Existing Tables 12.4.2 to Table 12.4.9 have been renumbered Table 12.4.3 to Table 12.4.10.

Chapter 13

Requirements for Welded Construction

Effective date 1 July 2011

■ *Section 1*
General welding requirements

1.11 Non-destructive examination of welds

1.11.1 Non-destructive examinations are to be made in accordance with a definitive written procedure prepared and endorsed by a person qualified according to a Nationally Recognised Scheme with a grade equivalent to level III qualification of ISO 9712, SNT-TC-1A, EN473, or ASNT Central Certification Program (ACCP). As a minimum, the procedure will identify personnel qualification levels, NDE datum and identification system, extent of testing, methods to be applied with technique sheets, acceptance criteria and reporting requirements. These procedures are to be ~~approved~~ reviewed by the Surveyor. *See* Ch 1,5.

■ *Section 2*
Specific requirements for ship hull structure and machinery

2.12 Non-destructive examination of welds

2.12.5 The method to be used for the volumetric examinations of welds is the responsibility of the Builder. Radiography is generally preferred for the examination of butt welds of 8 mm thickness or less. Ultrasonic testing is acceptable for welds of 8 mm thickness or greater and is to be used for the examination of full penetration tee butt or cruciform welds or joints of similar configuration. Advanced ultrasonic techniques, such as Phased Array Ultrasonic Testing (PAUT), may be used as a volumetric testing method in lieu of radiography or manual ultrasonic testing. If these methods are used, the thickness limitations for manual ultrasonic testing apply.

Table 13.2.4 Acceptance criteria for visual testing, magnetic particle and liquid penetrant testing (*Part only shown*)

Surface discontinuity	Classification according to ISO 6520-1	Acceptance criteria for visual testing
Surface pore	2017	Single pore diameter $d \le 0,25t$, for butt welds, with maximum diameter 3 mm, *see* Note 1 $d \le 0,25a$, for fillet welds, with maximum diameter 3 mm, *see* Note 1 2,5d as minimum distance to adjacent pore

Table 13.2.6 Acceptance criteria for ultrasonic testing (*Part only shown*)

Echo height	Acceptance criteria for ultrasonic testing, *see* Note
Indications evaluated to be cracks are unacceptable regardless of echo height; Indications evaluated to be lack of penetration or lack of root fusion in joints welded from one side are unacceptable regardless of echo height.	

■ *Section 4*
Specific requirements for fusion welded pressure vessels

4.13 Extent of NDE for Class 1 pressure vessels

4.13.5 When an unacceptable indication is detected, the full length of the weld is to be subjected to 100 per cent examination by the same method, testing conditions and acceptance criteria.

4.14 Extent of NDE for Class 2/1 pressure vessels

4.14.4 The requirements of ~~4.13.3 and 4.13.4~~ 4.13.3, 4.13.4 and 14.13.5 apply to Class 2/1 pressure vessels.

■ *Section 8*
Specific requirements for welded aluminium

8.1 Scope

8.1.1 This Section specifies requirements for the fabrication and welding of aluminium alloys, and is in addition to those detailed in this Chapter.

8.1.2 Fabrication and welding of these materials is to be in designated areas which are separated from those used for other materials, such as carbon steels, stainless steels and copper alloys. Where work is performed in the same workshop as other materials, adequate barriers or screening are to be provided to prevent cross-contamination of different material types.

8.1.3 All tools and equipment used are to be suitable for use on aluminium alloy materials. The use of tools made of carbon steel materials is to be avoided where possible.

8.2 Forming and bending

8.2.1 Aluminium alloys are to be subject to cold forming and cold bending only.

8.3 Fabrication and welding

8.3.1 Welding may be performed using gas tungsten arc welding (GTAW) or metal inert gas welding (GMAW), MIG/MAG welding (GMAW), or variants thereof. The use of other welding processes such as friction stir welding (FSW) will be subject to special consideration and will require submission of the process details, consumables and the weld properties achieved.

8.3.2 Misalignment may be corrected by the application of steady even force (e.g. using hydraulic or screw-type clamps). Hammering or heating is not permitted.

8.3.3 Correction of distortion by the application of heat is not permitted.

8.4 Non-destructive examination

8.4.1 The requirements of Ch 13,1.11 and Ch 13,2.12 apply; however, acceptance criteria applicable to aluminium are to be in accordance with Table 13.8.1 and Table 13.8.2.

8.4.2 Alternative NDE acceptance criteria will be subject to special consideration provided that they are equivalent to these requirements.

Table 13.8.1 Acceptance criteria for surface imperfections of aluminium

Surface discontinuity	Classification according to ISO 6520-1	Acceptance criteria
Crack	100	Not permitted
Lack of fusion	401	Not permitted
Incomplete root penetration in butt joints welded from one side	4021	Not permitted
Surface pore	2017	$d \leq 0{,}3s$ or $0{,}3a$ or 1,5 mm (whichever is the lesser)
Linear porosity (*see* Note 1)	2014	Not permitted
Uniformly distributed porosity (*see* Note 2)	2012	≤ 1% of area
Clustered porosity	2013	Not permitted
Continuous undercut	5011	$h \leq 0{,}1t$ or 0,5 mm (whichever is the lesser)
Intermittent undercut	5012	$h \leq 0{,}1t$ or 1,0 mm (whichever is the lesser)
Excess weld metal (*see* Note 3)	502	$h \leq 1{,}5$ mm + $0{,}15b$ or 8 mm (whichever is the lesser)
Excess penetration	504	$h \leq 4$ mm
Root concavity (*see* Note 3)	515	$h \leq 0{,}1t$ or 1 mm (whichever is the lesser)
Linear misalignment (*see* Notes 4 and 5)	507	$h \leq 0{,}1t$ or 1,0 mm (whichever is the lesser)
Angular misalignment	508	(*see* Note 6)

Symbols

a = nominal throat thickness of a fillet weld
b = width of weld reinforcement
d = diameter of a gas pore
h = height or width of an imperfection
s = nominal butt weld thickness
t = wall or plate thickness (nominal size)

NOTES

1. For this acceptance criteria, linear porosity is to be considered as three aligned gas pores in a length of 25 mm.
2. To be in accordance with EN ISO 10042.
3. A smooth transition is required.
4. Linear misalignment is to be a maximum of 0,5 mm in highly stressed areas. For other areas, the linear misalignment is to be a maximum of 1,0 mm locally, where the sum of the length of imperfection is not more than 10% of the weld length).
5. The limits for linear misalignment relate to deviations from the correct position. Unless otherwise specified, the correct position is that when the centrelines coincide.
6. Angular misalignment shall be mutually agreed between the designer and the fabricator.

Table 13.8.2 Acceptance criteria for internal imperfections of aluminium

Internal discontinuity	Classification according to ISO 6520-1	Acceptance criteria (*see* Note 1)
Crack	100	Not permitted
Lack of fusion	401	Not permitted
Incomplete penetration	402	Not permitted
Single gas pore	2017	$d \leq 0{,}3s$ or $0{,}3a$ or 5 mm (whichever is the lesser)
Linear porosity	2014	Assess as lack of fusion
Uniformly distributed porosity (*see* Note 1)	2012	$0{,}5 < t < 3$ mm $\leq$ 2% of area $3 < t < 12$ mm $\leq$ 4% of area $12 < t < 30$ mm $\leq$ 6% of area $t > 30$ mm $\leq$ 8% of area
Clustered porosity (*see* Note 1)	2013	$dA \leq 20$ mm or wp (whichever is the lesser)
Elongated cavity Wormhole	2015 2016	$l \leq 0{,}3s$ or $0{,}3a$ or 4 mm (whichever is the lesser)
Oxide inclusion (*see* Note 2)	303	$l \leq 0{,}5s$ or $0{,}5a$ or 5 mm (whichever is the lesser)
Tungsten inclusion	3041	$l \leq 0{,}3s$ or $0{,}3a$ or 4 mm (whichever is the lesser)
Copper inclusion	3042	Not permitted
Multiple imperfections in any cross-section	—	The sum of the acceptable individual imperfections in any cross-section is not to exceed $0{,}3t$ or $0{,}3a$ (whichever is the lesser)

Symbols

a = nominal throat thickness of a fillet weld
b = width of weld reinforcement
d = diameter of a gas pore
h = height or width of an imperfection
s = nominal butt weld thickness
t = wall or plate thickness (nominal size)
wp = width of weld or width or height of cross-sectional area
dA = diameter of area surrounding gas pores
l = length of imperfection in longitudinal direction of weld

NOTES

1. Porosity is to be determined in accordance with ISO 10042. The requirements for a single gas pore are to be met by all the gas pores within this circle. Systematic clustered porosity is not permitted.
2. If several oxide inclusions l_1, l_2, l_3, ... exist in one cross-section, then they are summed: $l = l_1 + l_2 + l_3 + ... + l_n$.

Chapter 14

Plastics Materials and other Non-Metallic Materials

Effective date 1 July 2011

■ *Section 1*
General requirements

1.1 Scope

1.1.2 These materials and products are to be manufactured and surveyed in accordance with the general requirements of Sections 1, 2 and 3 of this Chapter; and LR's *Materials and Qualification Procedures for Ships (MQPS) Book K*, *see* Ch 1,2.2.2, which, in addition to the test programme, also details the procedures for application for approval of manufacturers and products and details of the information to be supplied by the manufacturer.

~~*1.1.7* For the purposes of these Rules the following definitions apply:~~
~~(a)~~ ~~A 'plastics material' is regarded as an organic substance which may be thermosetting or thermoplastic and which, in its finished state, may contain reinforcements or additives.~~
~~(b)~~ ~~'Approved' or 'accepted' refers to materials which hold a valid Certificate, Statement of Acceptance, or Letter of Non-Objection issued by LR.~~

1.1.7 For the purposes of these Rules a 'plastics material' is regarded as an organic substance which may be thermosetting or thermoplastic and which, in its finished state, may contain reinforcements or additives.

1.1.8 Materials not listed in 2.1.1 may be considered for approval on a case-by-case basis. The approved test results will be listed on the issued certificate. Subject to satisfactory service experience and validation of approval, the material may be entered in 2.1.1 of the Rules.

1.3 Manufacture

1.3.4 In order to maintain approval, the manufacturer is required to confirm in writing that there have been no changes in the formulation or production process for the material in question and that the site of manufacture remains unchanged.

Section numbering in brackets reflects any Section renumbering necessitated by any of the Notices that update the current version of the Rules for Materials.

Chapter 10

*3.6.9 (**3.7.9**)*	*Reference* 3.8.1 *now reads* 3.9.1
4.2.1	*Reference* 3.2.4 *has been deleted*
*4.6.2 (**4.6.3**)*	*Reference* 3.5.2 to 3.5.16 *now reads* 3.6.3 to 3.6.20 *Reference* 3.5.4 *now reads* 3.6.5
*4.6.3 (**4.6.4**)*	*Reference* 3.5.5 *now reads* 3.6.6
*4.6.4 (**4.6.5**)*	*Reference* 3.5.10 *has been deleted*
*4.6.5 (**4.6.6**)*	*Reference* 3.5.17 to 3.5.19 *now reads* 3.6.21 to 3.6.23
*4.6.6 (**4.6.7**)*	*Reference* 3.5.20 *now reads* 3.6.24
*4.6.7 (**4.6.8**)*	*Reference* 3.5.21 to 3.5.25 *now reads* 3.6.25 to 3.6.29
4.7.1	*Reference* 3.6 *now reads* 3.7
4.8.1	*Reference* 3.7 *now reads* 3.8
4.9.1	*Reference* 3.8.1 *now reads* 3.9.1 *Reference* 3.8.2 *now reads* 3.9.2
4.10.1	*Reference* 3.9 *now reads* 3.11

Chapter 11

*3.11.3 (**3.10.3**)*	*Reference* 3.11.1 *now reads* 3.10.1 *Reference* 3.11.2 *now reads* 3.10.2
*3.11.5 (**3.10.5**)*	*Reference* 3.11.1 *now reads* 3.10.1 *Reference* 3.11.4 *now reads* 3.10.4

Chapter 12

4.1.3	*Reference* Table 12.4.2 *now reads* Table 12.4.3
4.1.6(a)	*Reference* Table 12.4.3 *now reads* Table 12.4.4
4.1.6(b)	*Reference* Table 12.4.4 *now reads* Table 12.4.5
4.1.6(c)	*Reference* Table 12.4.5 *now reads* Table 12.4.6 (twice) *Reference* Table 12.4.6 *now reads* Table 12.4.7
4.2.4	*Reference* Table 12.4.7 *now reads* Table 12.4.8
4.2.5	*Reference* Table 12.4.8 *now reads* Table 12.4.9
4.2.6	*Reference* Table 12.4.9 *now reads* Table 12.4.10

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